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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS.

W. O. ATWATER, DIRECTOR.

EXPERIMENT STATION BULLETIN No. 2.

DIGEST

OF THE

ANNUAL REPORTS

OF THE

AGRICULTURAL EXPERIMENT STATIONS

IN THE

UNITED STATES

FOR

1888.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

PART 1.

JUNE, 1889.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1889.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., June 15, 1889.

SIR: In accordance with the acts of Congress and the directions of the Secretary of Agriculture in conformity therewith, it is the duty of this office not only to indicate lines of inquiry and furnish such advice and assistance as will best promote the objects for which the Agricultural Experiment Stations are established, but also to "compare, edit, and publish such results" of their work as may be deemed necessary.

I have the honor to transmit herewith, for publication, Experiment Station Bulletin No. 2, of this office, which is Part I of a Digest of Annual Reports of the Stations for 1888.

Respectfully,

W. O. ATWATER,
Director.

Hon. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

PURPOSE AND PLAN OF THIS BULLETIN.

To meet the demand for compilations of the work of the Agricultural Experiment Stations in this country, the present summary of the Annual Reports of the Stations for 1888 is issued.

Three plans for such compilations by this office suggested themselves. One was to attempt a digest of the publications of the stations from the outset of their work until the present. To bring such a compilation up to date at an early day would require much larger resources than were available, and, even if accomplished, would be unsatisfactory unless the results of the very large amount of cognate work done by European stations and by other institutions on both sides of the Atlantic were included. Another plan would include simply accounts of the contents of current bulletins of the stations. To commence with the bulletins of the present year would be to neglect much that demands immediate notice. The middle course, of commencing with a summary of the Annual Reports of the Stations for 1888, seemed most advisable. These reports generally include what has been given in the bulletins of that year and considerable other matter in addition. A number of the reports for 1888 fortunately contain summaries of work accomplished before the National Government gave its aid to the enterprise. Taken together, therefore, they present a wider and truer view of the results already obtained by the stations in this country than would otherwise be found in the publications of a single year.

A number of the reports have not been published or, if issued, have not reached this office. It has seemed best to issue the first part of this bulletin without further delay and reserve the remainder to be published at the earliest practicable date as the second part of the same volume.

This summary of experiment station reports is itself an experiment. The object has been to reflect as accurately and fully as might be the accounts which the stations have rendered of their work. To this end the report of each station has been treated by itself, with only such comment as is needed to connect the several parts. A topical arrangement would perhaps be more logical, and may be followed in later publications. But experience in such matters implies that if the table of con-

tents and index are satisfactory the order of subjects is of minor importance.

It will also be observed that the widely varying ideas as to what the annual reports of the stations should contain are reflected in these summaries. It seems desirable that the stations should reach some consensus as to what shall be included in their annual reports. Until this is done the compilations of station work made by this office can hardly attain a satisfactory degree of uniformity and orderly arrangement.

Details of several classes of subjects, such as field and feeding experiments and analyses of feeding stuffs and fertilizers, the especial value of which would otherwise have called for their insertion even in this report, have been omitted or only referred to, in the expectation that their main features would be included in special bulletins, the publication of which is now contemplated or undertaken.

The financial reports of the stations have been reserved for Part II, in order that they may be presented in such a manner as to make them easily comparable.

The reports of the individual stations herein given have been arranged according to States in alphabetical order.

Suggestions regarding the digests and the index are cordially invited. Errors in statements of facts or figures will be gladly corrected in later issues.

OTHER PUBLICATIONS OF THE OFFICE OF EXPERIMENT STATIONS.

Experiment Station Bulletin No. 1 of this office, issued in February, 1889, gives accounts of the establishment, organization, officers, and revenues of the stations and of the organization and work of this office. Miscellaneous Bulletin No. 2, now in press, will contain a more detailed account of the experiment stations and agricultural schools in this country and of the Department of Agriculture. Circular No. 12 of this office contains a statement of the publications which it has thus far undertaken.

Digests of station bulletins of the current year are already begun and will probably be issued in parts with continuous paging, so that the numbers of a single year will make a convenient volume. It is intended to include other information in this publication and to make it a current record of matters of interest to experiment station workers and others. Its exact character will naturally shape itself to the demands and results developed by experience.

THE EXPERIMENT STATION ENTERPRISE.

A review of the present digest of annual reports of the stations, taken in connection with other indications of their character and operations, leads to several conclusions regarding the experiment station enterprise in the United States, of which the following may be noted here.

First of all it is to be observed that the annual reports for 1888 are not a fair exhibit of a year's work. Most of the stations are new. Of the forty-six or, counting branch stations, fifty-seven stations now in operation, only twenty were organized previously to 1888, when the act of Congress providing \$15,000 per year for each State for the purpose came into effect, and it was not until the spring of that year that the appropriation was made available. Much of their first effort was devoted to such preparation as wisely precedes the actual work of investigation. A large part of the experimental inquiry undertaken is in the nature of the case not ready to be reported upon. The research which in the end proves the most useful is generally the hardest to get under way and the slowest to complete. Consequently, the results reported by the stations represent only a part of the work actually done. And, furthermore, the annual reports do not in all cases include all the experimental results that have been published by the stations.

It is to be further noted that some reports are detailed, others condensed. Some stations have attempted many lines of inquiry, others have concentrated their energies on a few. Neither the number of investigations undertaken by a given station, nor the length of its report, nor the length of the summary here given is a measure of the real usefulness of the station.

From these and other considerations it is evident that it would be unjust to judge either of the relative merits of the several stations or of the importance of the movement as a whole by such a summary of annual reports of a given year, even if the summary were a perfectly fair and full exhibit of the contents of the reports.

The prospects of the experiment station enterprise in the United States are, on the whole, very encouraging. There are, indeed, difficulties and dangers. Among these are political complications which have, in individual cases, worked serious injury; the crudeness that comes of inexperience; the smallness of the number of trained specialists in comparison with the suddenly enlarged demand; the lack of libraries and other appliances; the fact that the immense amount of experience already required is for the most part recorded in foreign languages and in books to which few station workers have access; the limited opportunities which the station workers have for contact with each other and with other specialists in their several lines; the popular demand for a large number of immediate practical results, a demand which is entirely natural, but which leads and almost compels some of the stations to study a large number of general questions superficially, instead of concentrating their energies upon a few narrow and specific problems, and following out the inquiries until the fundamental laws which underlie them are discovered.

As regards the scientific character of their work our stations are doing just what the European stations did in their early experience. They are selecting questions of immediate practical interest and study-

ing them in the most direct ways because they feel that they must, and neither they nor their constituencies have found by actual experience how often this method fails. The difficulty is that the seemingly simplest and most pressing problems reach down to the profoundest depths of abstract law; that often the things which appear theoretical are at the bottom the most essential, that not infrequently the practical interests of the farmer require the theoretical problems to be considered first, for the same reason that the foundation of a house and not the wall is first to be built.

“Unquestionably the stations ought to make practical experiments in the study of the problems before them. But in the long run those stations will do best that plan their work most philosophically, and the prosperity of the enterprise as a whole will be proportioned to its success in the discovery of the laws that underlie the right practice of agriculture.”

Inexperience will cause waste and loss in experiment station work as it has done in the settling of our new territory, the building of our railroads, the organization of our manufactures, and in countless other enterprises of our new national life. The redeeming feature is in our power to learn and to apply what we learn.

Indeed, no one who is familiar with such subjects can read the reports of the stations for the past year without seeing that the usefulness of the work already accomplished more than repays its cost, and that the prospects for constantly increasing usefulness are most encouraging. That so many stations should in so short a time perfect their organization and enter upon lines of inquiry of prime importance to the communities in which they are located, in itself shows that in the forces controlling and guiding this movement there are the energy and wisdom needed to carry it to a successful issue. This confidence is greatly increased by the consideration of other phases of the station enterprise, which we can only briefly enumerate here. We can avail ourselves of the fruits of many years of labor and experience of experiment stations and other institutions in this country and in Europe. The American is quick to grasp new ideas and has a peculiar ability to adapt himself to new conditions. The experiment station in this country is being established on a broader basis than in Europe. Even the excessive number and wideness of the questions with which our stations are in many cases beginning, has the compensating advantage that the wants of our agriculture will thus come to be more clearly understood, and the ways the stations can meet them will be more quickly learned. While the science of agriculture has been less studied in this country, and there are fewer investigators on this side of the Atlantic than on the other, there are nowhere abler or more devoted workers than we have. Our young investigators are full of earnestness and enthusiasm, and many of them combine in their experience the advantages of both home and foreign training. Leaders, even in German science, who have watched our

young men, and the development of research in our midst, prophesy that American science will one day excel their own. Most of our stations are connected with educational institutions, where experience shows that their work is most advantageously done. The Association of American Agricultural Colleges and Experiment Stations is a wise, earnest, and powerful agency in helping the stations to fulfill the purpose for which they were founded. The United States Department of Agriculture, pursuant to the act of Congress, will likewise be able to do much to aid the experiment stations in the co-ordination of their work, in their use of the results of experimental research, in their relations to each other, and in their connection with the agricultural public. The demand for what the stations can supply is widespread and rapidly increasing; the popular taste really approves what is best, and it is a significant fact that as the stations have become known they have uniformly increased in popular favor, and have received more and more substantial support.

DIGEST OF THE ANNUAL REPORTS OF THE AGRICULTURAL EXPERIMENT STATIONS IN THE UNITED STATES FOR 1888.

ALABAMA.

Agricultural Experiment Station of the Agricultural and Mechanical College of Alabama.

Department of the Agricultural and Mechanical College of Alabama.

Location, Auburn.

Director, J. S. Newman.

ANNUAL REPORT FOR 1888.

REPORT OF DIRECTOR (pp. 4-6).—The Agricultural Department of the Station was organized by the State, July, 1883, and reorganized under National authority, April 1, 1888. The farm of 226 acres when purchased in 1883 was in a very dilapidated condition; much of the land had been turned out as commons and a large portion was corrugated with gullies. The permanent improvements are dwellings for the director and foreman, a cottage containing offices and a museum, a substantial two-story barn, a gin-house, silo, dairy, and icehouse, large cow stable, engine and boiler house, corn-crib, tool-rooms, etc. The water supply for the greenhouse and horticultural grounds is furnished by two hydraulic rams, which utilize the waste from two fish-ponds. The equipment includes a twenty-horse-power boiler and fifteen-horse-power engine, gin with feeder and condenser, power-press, feed-mill, cotton-seed crusher, ensilage cutter, grain separator, complete dairy equipment, etc.

The live stock includes thoroughbred Jersey cows, and thoroughbred Essex and cross-bred Berkshire pigs.

In the Horticultural Department a large number of varieties of apples, pears, peaches, plums, figs, grapes, strawberries and raspberries are being tested as to their comparative productiveness and adaptation to the soil and climate of Alabama.

Field experiments have been made with fertilizers, cotton, corn, forage plants, small grain, ground-peas, sweet and Irish potatoes, melons, and garden vegetables. Especial attention has been given to the underground growth of cultivated plants and the effects of different methods

of cultivation upon this growth and the consequent productiveness of the plant.

REPORT OF CHEMIST, N. T. LUPTON, LL. D. (pp. 7, 8).—The Chemical Department of the Station includes the chemist and three assistants.

In addition to the work directly connected with the Station, the chemist is professor of general and agricultural chemistry in the Agricultural and Mechanical College and official chemist of the State Department of Agriculture. On the application of the Commissioner of Agriculture he is required by law to "analyze and certify the analysis of all fertilizers, samples of which are furnished him, and at the request of the Commissioner, if he can without conflict with his duties as professor, must attend conventions of agricultural chemists, make reports of such matters as he may deem of interest to the Department, and render such other services in the line of his profession as the Commissioner may require." * * * The variety and character of this (chemical) work may be seen from the following tabular statement of the number and character of the quantitative analyses made during the year 1888:

Substances analyzed.

	Number.
Acid phosphates with nitrogen and potash.....	84
Acid phosphates with potash.....	8
Acid phosphates	57
Raw bone meal	2
Natural guanos	18
Phosphatic rocks and deposits.....	1
Marls and calcareous rocks.....	5
Tankage.....	1
Cotton-seed meal.....	3
Cotton-seed hull ash	1
Cave earths.....	3
Kainit and potash salts	8
Feed stuffs.....	3
Nitrogenous materials.....	5
Carbonaceous matter, or muck	1
Potatoes.....	9
Soils and subsoils	20
Coal.....	5
Iron ores.....	2
Clays.....	4
Waters	1
Gold ores	2
Total.....	243

In addition to the above, a considerable number of mineralogical specimens, the character of which could be ascertained by simple qualitative tests, were examined and their value determined.

DEPARTMENT OF BOTANY AND METEOROLOGY, P. H. MELL, PH. D. (pp. 9, 10).—The botanical work reported includes collections of wild plants of the county where the college is located, two bulletins containing partial lists of Alabama woods, with descriptions of some of the most valuable specimens, classification of noxious weeds of eastern Alabama, and microscopical and other studies of the fiber of the cotton plant.

The work in meteorology was begun in 1884. The equipment includes—

A mercurial barometer by Green, carefully corrected and compared with the standard at Washington; maximum and minimum thermometers by Green; hygrometer; terrestrial radiator; solar radiator; rain-gauge, standard make; anemometer with electrical recorder by Gibbon; wind-vane, Signal Service pattern; three sets of soil thermometers ranging in depth from 1 to 96 inches.

Besides the Station at Auburn, reports are received from twenty-six observers in different sections of the State, who are supplied, through the liberality of the Chief Signal Officer, with maximum and minimum thermometers and rain-gauges. From the data obtained from these observers regular monthly bulletins have been issued since 1884, and distributed among the farmers of the State.

Canebrake Agricultural Experiment Station.

Department of Agricultural and Mechanical College of Alabama.

Location, Uniontown, Ala.

Director, J. S. Newman.

Assistant Director in charge, W. H. Newman, M. Sc.

ANNUAL REPORT FOR 1888.

REPORT OF DIRECTOR (pp. 5-8).—The report contains an account of the organization of the Station, its sources of income, the permanent improvements made during the year, and the equipment.

This station was organized under the State law in the spring of 1885. It had its origin in a demand for the investigation of the needs of the peculiar calcareous soils known as the prairie region, and especially that part of the prairie known as the Canebrake, which, once celebrated for its fertility, has by injudicious cultivation, been seriously impoverished.

Experiments.—The work in this respect has been directed mainly to practical questions of economic bearing rather than to original investigation. Corn, cotton, and small grain have received especial attention as regards methods of preparation, planting, cultivation, and harvesting, and the comparative merits of varieties.

The forage crops adapted to this soil and climate have received attention with special reference to seasons and manner of planting fertilizers suited to them, and the best methods of utilizing them, and their effects upon the productiveness of the soil. The comparative merits of clover, *Melilotus alba*, and field peas as soil renovators are being investigated on soils too poor for profitable cultivation.

In the interest of horticulture and pomology much care has been devoted to experiments with varieties of vegetables, melons, small fruits, apples, pears, peaches, and grapes. The details of results of experiments have been published and distributed in bulletins.

ARKANSAS.

Arkansas Agricultural Experiment Stations.

Department of Arkansas Industrial University.

Location, Fayetteville.

Director, A. E. Menke, D. Sc.

Branch stations at Pine Bluff, Newport, and Texarkana.

FIRST ANNUAL REPORT.

FIELD EXPERIMENTS.—(1) *With corn and cotton* on the farm of Mr. Bordeaux, in Drew County, showing the manurial value of certain fertilizers and the effects of cultivation as a protection against drought (pp. 7-9).

(2) *With wheat*, to determine the relative yield of different varieties and the relative value of fertilizers (pp. 35-40).

(3) *With peas*, to determine the comparative yield and earliness (p. 40).

(4) *With potatoes* (pp. 59-68).

Table showing the results of experiments with the most productive varieties of potatoes.

FAYETTEVILLE—UNFERTILIZED.

Variety.	Date of planting.	Date of blooming.	Date of digging.	Yield in bushels per acre.			Weight per bushel.	Total yield at Texarkana.	Per cent of starch at Fayetteville.	Per cent of starch at Texarkana.
				Large.	Small.	Total.				
Rural Blush	Mar. 20	May 28	July 27	179 $\frac{7}{8}$	16 $\frac{1}{2}$	196	Lbs. 61	Bu. 39	72.44	67.67
Empire State	do	do	do	166 $\frac{3}{4}$	.....	166 $\frac{3}{4}$	58	95	70.03	67.26
Dictator	do	June 2	do	159 $\frac{1}{2}$	15 $\frac{1}{2}$	175	56	95	.....	69.35
American Giant	do	May 24	do	156	12	168	54	95	68.11	69.36
Dakota Red	do	do	do	154 $\frac{3}{4}$	.....	154 $\frac{3}{4}$	58	114	.....	70.09
Early Maine	Mar. 22	May 23	do	142 $\frac{1}{2}$	9 $\frac{1}{2}$	151 $\frac{3}{4}$	62	140	.....	68.13

TEXARKANA—UNFERTILIZED.

Variety.	Date of planting.	Date of blooming.	Tops died.	Yield in bushels per acre.			Total yield per acre.	Total yield at Fayetteville.	Per cent of starch at Fayetteville.	Per cent of starch at Texarkana.
				Large.	Medium.	Small.				
Rose's Beauty of Beauties	Mar. 22	June 4	July 3	68	47	31	Bu. 146	Bu. 112 $\frac{1}{2}$	.....	66.70
Triumph	Mar. 20	May 29	July 2	86	44	13	143	77	69.21	69.82
Early Maine	Mar. 22	May 28	June 23	79	31	30	140	151 $\frac{3}{4}$	.....	.....
Chicago Market	Mar. 20	June 8	June 27	63	33	22	118	135 $\frac{1}{2}$	.....	68.70
Dakota Red	do	June 9	June 26	66	33	15	114	154 $\frac{3}{4}$	.....	.....
White Star	do	June 7	July 1	58	37	16	111	134	71.60	67.75

The two most profitable mixtures of fertilizers for potatoes in the experiments were (per acre): 400 pounds cotton-seed meal, 300 pounds kainit, and 300 pounds superphosphate; and 400 pounds ammonia salts, 300 pounds kainit, and 300 pounds superphosphate.

(5) *With cotton* (pp. 99-119).—Co-operative experiments were performed in different parts of the State to determine the best fertilizers and methods of cultivation.

The average results obtained from the use of chemical fertilizers are summed up in the following table :

Fertilizer, average pounds per acre.	Average yield seed cotton per acre.	Average yield lint per acre.	Cost of fertilizers.
166.6 cotton-seed meal. } 166.6 acid phosphate. } 41.6 chloride of potash. }	983.3	327.7	\$3.10
166.6 cotton-seed meal. } 166.6 acid phosphate. } 166.6 acid phosphate. }	851	283.7	2.17
41.6 chloride of potash. } 166.6 cotton-seed meal. }	846.6	282.2	2.02
41.6 chloride of potash. } 166.6 cotton-seed meal. }	810	270	2.02
275 cotton-seed meal. } 275 superphosphate. } 70 chloride of potash. }	805	268.3	5.50
275 cotton-seed meal. } 275 superphosphate. }	755	251.6	3.93
210 cotton-seed meal.....	697	232.3	1.36
200 acid phosphate.....	695	231.6	1.30
83.3 sodic nitrate.....	650	216.6	2.49
71 ammonic sulphate.....	640	213.3	2.48
53 chloride of potash.....	616	205.3	1.21
230 kainit.....	588	188.6	1.38

These data are naturally calculated from the results obtained in different parts of the State, and must be taken tentatively as indicating the way in which fertilizing work should be done. In certain instances it will be noticed that occasionally an individual result is higher than the average, and perchance on that particular piece of land the fertilizer that gave the highest result might be the more desirable; but for those who wish to be safe we most decidedly recommend the use of the mixture giving the highest average results. Next year we shall continue our work in this direction. We advise, conditionally, the following chemical formula for cotton per acre: 200 pounds cotton-seed meal, 200 pounds acid phosphate, and 50 pounds chloride of potash.

The following table shows the results of tests of varieties of cotton made at Texarkana :

Variety.	Planted.	Commenced to bloom.	Commenced to open.	Pounds of seed cotton per acre.	Pounds of lint per acre.	Pounds of seed per acre.
Hawkins	April 16 ..	June 29...	August 3..	444	144	300
Peerless	do	July 16...	August 1..	558	192	366
Ozier silk.....	do	June 30...	August 3..	534	162	372
Jones	do	do	August 4..	582	186	396
Crawford	do	July 2	August 5..	594	192	402
Peterkin.....	do	July 8	August 14.	552	216	336

The Peerless cotton seemed to mature a little before the other varieties. The Peterkin stood the drought fairly, but did not do so well during the rainy weather; it is a slow grower until the warm weather sets in.

(6) *With mangel-wurzels and corn*, to determine the comparative yield of different varieties (pp. 119, 120).

EXPERIMENTS WITH SORGHUM (pp. 68-90).—A series of preliminary experiments with some sixty varieties to determine the percentage of sucrose in the cane, the effect of fertilizers on the sugar content, and the methods for increasing the sugar content. The result is stated in tabular form.

COMMERCIAL FERTILIZERS (pp. 13-21).—Descriptions of common varieties, cost of ingredients at factories in Memphis and St. Louis, and a table of analyses made at the Station.

ANALYSES OF FODDERS grown in the State, with tables showing percentages of constituents (pp. 130-133).

DEHORNING (pp. 22-35). (Illustrated.)—The conclusions arrived at from a number of experiments are thus formulated:

- (1) The operation requires some care, but is not difficult or dangerous.
- (2) The wounds heal favorably, as a rule, although in exceptional cases and when the operation is improperly performed continued suppuration and chronic inflammation may ensue and seriously interfere with the health of the animal.
- (3) In cases that progress normally, from three to four months may be given as the time which elapses before complete healing occurs.
- (4) When amputated at the proper place the horns do not return.
- (5) The constitutional disturbance is not severe, and is manifested by a slight and temporary rise of temperature, with, probably, in most cases, a slight decline in weight and milk secretion, lasting over the first week or so.
- (6) The quality of the milk is not injuriously affected.
- (7) The operation must be considered painful, but there is no evidence that the pain is excessive after the operation is over.

On calves we conclude that—

- (1) The operation is less painful than in adults.
- (2) When removed as above directed the horns do not return.
- (3) There is little constitutional disturbance manifested.
- (4) When the animal is healthy the wounds heal favorably in about six weeks or two months.

TEXAS FEVER and other diseases of animals (pp. 91-99).

HORTICULTURE.—*Grapes* (pp. 41-50).—One hundred and sixty-five varieties were set out. Many of the vines were affected with downy mildew, and were sprayed with Eau Celeste with satisfactory results. The vineyard is on a hillside, with a southeastern exposure. The soil is loamy, with a clay subsoil. The report contains a list of varieties planted, with notes on their condition.

Strawberries (pp. 50-55).—List of forty-three varieties planted, with per cent of live plants and notes on their condition.

At branch station, at Pine Bluff, one hundred and seventeen varieties of grapes and forty-two varieties of strawberries were planted. A list of these varieties is given, with notes on their condition.

List of fruits and shrubs growing on the station grounds (pp. 56-58).

REPORT OF ENTOMOLOGIST, C. W. WOODWORTH, B. S. (pp. 121-130).—Illustrated articles on the Grape-Leaf Folder (pp. 122-127) and the Apple-Leaf Rust (pp. 127-130).

Peach-Tree Borer and Codling Moth (pp. 9-13).—Description of the insects and account of methods to prevent their ravages.

COLORADO.

Agricultural Experiment Station of Colorado.

Department of the State Agricultural College.

Location, Fort Collins.

Director, Charles L. Ingersoll, M. S.

FIRST ANNUAL REPORT, 1888.

HISTORY AND ORGANIZATION (pp. 5-8).—In planning for the organization and work of the Station, after due consideration, the State Board of Agriculture deemed it advisable to provide for the location of the main station at the college, and outside stations, as fast as organized, to be made auxiliary to it.

Two auxiliary stations were organized the first year; one at Del Norte, in Rio Grande County, and known as the San Luis Valley Agricultural Experiment Station; and the other at Rocky Ford, in Bent County, and known as the Bent Agricultural Experiment Station. Nothing has been done at either of these auxiliary stations in the line of experimentation, except to take observations of temperature and rain-fall. Work has been done preparatory to carrying on a line of investigation at these stations next year.

OUTLINE OF EXPERIMENTS PLANNED FOR 1888 (pp. 9-16).

Agricultural section.—Plans for experiments and other use of experimental ground:

I. Tests for soil variation; twenty-five plats, thirteen (manured) to corn, twelve (unmanured) to wheat. II. To provide samples for chemical analysis to compare nutritive value of plant at different periods of growth; twenty-five plats, eighteen to grasses, seven to clovers. III. Field of clover for farm use. IV. Seven acres divided into one-half acre plats (manured), for cereals, forage plants, sorghum, vegetables, etc., for seed distribution. V. Field of corn for seed distribution. VI. Tile drainage (glazed and unglazed tiles) in old pasture. VII. Forty acres in oats. VIII. Piece of land transferred to horticultural department. IX. One hundred hop sets to be planted for test hop-yard. X. For report of outdoor tests of vitality of seeds. XI. To test chemical remedies proposed for rust, smut, mildew, etc. XII. To improve grains and other plants, by selection, and to make sure of correct names for seeds and plants sent from the college. XIII. To provide hay and pasture for stock kept.

Horticultural section.—(1) Scientific experiments. The weeds of the State; injurious insects; fertilization and cross-fertilization of useful plants, to improve varieties; leafage, growth, hardiness, and availability of the fruit and forest trees in Colorado. (2) Popular experiments; culture and curing of tobacco; culture and distillation of peppermint; culture of improved varieties of the potato; bee-keeping; subirrigation. (3) The planting of a nursery of large and small fruits for experiment

and distribution ; an experimental pear and plumb orchard ; a large variety of garden vegetables for seed distribution.

Chemical section.—Analyses of fertilizers and artesian water, and, with other departments, water, soils, sugar-beets, sorghum, grasses, other forage plants, and alfalfa.

Section of meteorology and irrigation engineering.—(1) *In meteorology*, besides the ordinary regular observations, influence of western winds in increasing temperature and accelerating evaporation, difference between the humidity of temperature of the air on irrigated and unirrigated land, rate and amount of cooling of earth and lower strata of the atmosphere at night.

Observations relating to irrigation.—Extent of cooling of soil due to irrigation and subsequent evaporation ; difference between irrigated and unirrigated fields as regards temperature of soil ; temperature of water in river, canal, lateral, and while flowing over field, to determine relative loss from evaporation ; rate of loss from reservoirs from evaporation alone, and from evaporation and percolation combined ; evaporation from soil surface.

(2) *In irrigation.*—The date irrigation begins and ends ; the amount used each month and the total volume for the year ; distribution from canals ; to test and report on measuring devices in common use ; and subirrigation experiments in connection with Horticultural Department.

REPORT OF DIRECTOR (pp. 17–23).—The report contains notes showing how far the plan of work for 1888 was carried out.

REPORT OF AGRICULTURIST, A. E. BLOUNT, A. M. (pp. 25–55).—(1) *Tests for soil variation*, to continue through a series of years. The crops to be “Pride of the North” corn, thirteen quarter-acre plats (manured), and “Amethyst” wheat, twelve plats (unmanured). For four years previous these plats had been used for various crops in rotation. Entire field plowed in fall and stable manure (two loads per plat) spread in winter on thirteen plats. April 24 these plats were pulverized by a clod crusher made for the purpose, harrowed, and planted May 1, 2, and 3 with $1\frac{1}{4}$ pounds of corn per plat. Extreme dryness of soil and chaffy character of manure caused slow and poor germination, about May 20. The corn was cultivated both ways with a five-tooth cultivator, in all five times between June 6 and August 3, and hoed once August 2. July 20 water was let on, but was stopped when half the plats had been reached. Crop harvested September 24–26 ; husked in November.

Table of results.

Plat No.	Green stalks and corn.	Dry fodder.	Corn in ear.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1	1,090	338½	286
2	1,000	419½	577
3	910	380½	279
4	800	266½	236½
5	725	291½	312
6	700	236½	208½
7	740	335	242
8	770	347½	226½
9	965	462	261½
10	1,050	457	285
11	1,115	323	268
12	830	364	140½
13	845	280	204
	11,540	4,500½	3,376½

This shows that about 67 per cent of water had dried out, and that the dried fodder weighed about 75 per cent more than the corn in the ear.

The wheat plats were pulverized and harrowed March 13; two plats were sown March 20, and ten March 21, 10 pounds of seed per plat, 2 inches deep. No cultivation was given the crop. The seed germinated in eighteen, twenty, and twenty-two days; slowness due to dryness of soil.

First irrigation June 15-18; second, July 5-10. Owing to an overflow of water about one-half of plat 25 was irrigated the previous fall. The result was that the wheat on the irrigated portion of that plat ripened nine days earlier than any other, and was much plumper and of a lighter color. It was cut and shocked August 2. The other plats were cut and shocked August 16-18. After eleven or twelve days the grain was weighed and stacked at the barn. Thrashing, September 25.

Table of results.

Plat No.	Weight when stacked.	Weight of straw.	Weight of grain.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
14.....	635	339	296
15.....	725	383	343
16.....	575	276½	298½
17.....	835	476½	358½
18.....	390	190	200
19.....	700	410	290
20.....	590	296	294
21.....	775	424	351
22.....	575	286½	288½
23.....	743	375½	359½
24.....	850	488	362
25.....	885	488½	396½
	8,270	4,432½	3,837½

Machine measure, 3,480 pounds, or 58 bushels.

By weight, 3,837½ pounds, or 62.9 bushels.

As regards water, these experiments seem to show that *too much has been generally used*.

(2) *Twenty-five plats were sown to grasses and clovers*, but very largely failed to show results owing to lack of water. Alfalfa and sainfoin, however, did fairly well.

(3) *The experiments with cereals, forage plants, sorghum, vegetables, etc.*, were failures or inconclusive.

(4) *Experiments with insecticides, etc.* Paris green on the web-worm, and kerosene emulsion for lice on sorghum proved effective. Corn soaked in a solution of water and strychnine was a sure remedy against ground-squirrels.

(5) *Out-door tests of seeds.* The following were planted: 260 varieties of wheat, 52 of oats, 34 of barley, 12 of rye, 15 of corn, 42 of peas, 3 of beans, 5 of buckwheat, 8 of millet, 6 of flax, 1 each of lentils, lupins, vetches, hop seed, sunflower, hemp, canary, mustard, chuna, fenngreek, chickpea, Aztec coffee. Tables are given, showing, for each variety of wheat, oats, and barley, the number of grains germinated, the yield of grain and straw, and the number of days between planting and ripening.

The following shows the varieties of wheat, oats, and barley found to be identical:

Wheats:

Eldorado = Egyptian.

Soft Australian = Hard Australian.

Golden Globe = Mediterranean Spring = China Tea.

Prussian = Golden Drop.

Triticum = Samara = Durim = Ames.

Rural = Peerless (?) = Sibley's No. 1 (?).

Oats:

Australian = White Eureka = Welcome = Clydesdale = Racehorse =
Burpie's Welcome = Waterloo.

Chinese Hulless = Bringle's Hullness.

Barley:

Smooth Hulless = Del Norte.

Winnepeg No. 1 = Phoenix.

Annat = Sibley's Purple.

Indian No. 4 = 4-rowed Spring.

REPORT OF HORTICULTURIST AND BOTANIST, JAMES CASSIDY, B. S. (pp. 57-150).—The report includes notes on tobacco, apple-twig blight, orchard and small fruits, garden vegetables, and leafage and maturity of fruit and ornamental trees.

Notes on tobacco (pp. 58-64).—Thirteen varieties were grown, ten of which came from the U. S. Department of Agriculture. "The soil is a clay loam that had been in clover sod for three years, and was plowed

under the fall previous, and again in the spring before planting." Cost of producing one acre of tobacco in Colorado :

Interest on land	\$6.00
Plowing and fitting the soil	3.00
Eight thousand plants, at \$4 per 1,000	32.00
Planting.....	4.00
Irrigating	2.00
Cultivating and hoeing.....	5.00
Worming, topping, and suckering.....	6.00
Cutting and hanging.....	10.00
Stripping and tying	10.00
Hauling to market, per mile.....	50
Total.....	78.50

Seed was sown in a moderate hot-bed April 15, and afterwards transplanted into another bed. This transplanting is not essential, but assures plants of equal vigor.

"We are satisfied that any of our upland soils are rich enough to produce a good crop of tobacco without manure for the present." All the varieties tested ripen perfectly, but "White Burley" is recommended as easiest to manage. Planting in open ground occurred May 29. Only one or two irrigations were needed to get the plants established. White Burley and Havana seed-leaf will be fit to cut not later than September 1. Practical directions for the management of this crop are given in the report.

Notes on apple-twigg blight (pp. 64-70).—"The disease appeared in the neighborhood of Fort Collins the latter part of June and continued to be more or less virulent until late in August." The report contains an account of the theories regarding this disease, its effects, and proposed remedies.

Notes on culture of orchard and small fruits (pp. 70-79).—Practical directions regarding the following topics: Location and soil; varieties to plant; planting and pruning; irrigation and after care; insects and diseases.

Notes on leafage of orchard and ornamental trees and shrubs (pp. 79-98).—The report contains a list of the orchard and small fruits grown at the college, and tables showing the dates of formation and maturity of leaves for a large number of varieties of apple and pear trees in 1887 and 1888, and for a considerable number of ornamental and useful trees and shrubs in 1888, with remarks as to their appearance, condition, and value.

Notes on vegetables (pp. 99-150).—Insects new to Colorado are the garden web-worm (*Eurycreon rantalis*), the bogus chinch-bug (*Nysius angustatus*), and the squash-bug (*Coreus tristis*).

Potatoes (pp. 100-117).—The tests were tried with one hundred and forty-six named varieties, for the most part hitherto untried in Colorado, and one hundred and five seedling varieties, to determine their value on a clay loam soil.

Both were planted on the same date, May 11. The area of ground devoted to these kinds was exactly one-half acre, in two separate plats of one-fourth of an acre each. The soil, a clay loam, had been in clover sod for two years previous and was plowed in the fall of 1887, and again early in the spring of 1888. The season was unfavorable owing to the lack of the usual rains in July, and to the presence of blight late in the fall. The tubers of the named kinds were cut to small one-eye pieces because of having but a limited number of a kind. Of the seedlings whole sets were used in all cases.

The seedlings appeared above ground five days earlier than the named kinds which were cut to one-eye sets and had generally but one stalk to a hill. The former were much the more vigorous throughout the season, and had two to six stalks to a hill. The two stalks were irrigated on the following dates: May 23, June 11 and 26, July 5, 12, and 20, and were dug September 21. They were cultivated four times and sprayed with Paris green three times. The yield was light for reasons already given, so that an estimate of values would be misleading. On suitable soils and in the hands of other growers many of these seedlings equaled or excelled the product of the most profitable named kinds, grown side by side. It is safe to say, however, that such varieties as proved reasonably productive this season under the conditions imposed would on deep sandy loams produce profitable crops of tubers. In the culture of this plant with irrigation a suitable soil is of more importance than its fertility.

Seedling potatoes and crosses.—Over five hundred seedling potatoes were raised this year, and planted in the open air early in June. A large proportion of these bore no tubers at all, and of such as did one hundred varieties will be planted another season. A few kinds bore tubers weighing one-fourth of a pound each. Several tubers of the Mexican or Central American potato were planted uncut May 28; they grew luxuriantly and produced balls in abundance, but bore no tubers. The latter, when dug, were as perfect as the day they were planted, but soon shriveled on being exposed to the air.

The potato in tuber and vine resembles the cultivated species very closely, of which it is without doubt a wild form. One tuber of *Solanum maglia* was also planted. It made a vigorous growth and blossomed freely, but bore neither pollen nor tubers. It also resembles the cultivated potato, but is much less vigorous. Its flowers are white, and the trusses and individual flowers of good size.

The hybridized seed of last year was sown in the greenhouse in April, the plants potted and set in the ground May 28. The progeny exhibited much variation in foliage, grew vigorously, but bore very few tubers and these were very small.

Tables are given showing number of hills for both named and seedling varieties, length and character of vine, condition of vine at digging, date of blooming, color of bloom and tuber, arrangement of tubers in hill, yield in pounds, shape of tubers, position of eyes, etc.

Onions (pp. 118–121).—Notes on nineteen varieties, with table showing from whom purchased, yield of 115 feet of row, estimated yield per acre, shape, color, and quality of bulbs, etc.

Peas (pp. 122–125).—Notes on thirty-seven varieties, with table showing from whom purchased, date of blooming, date of marketable maturity, date of ripening of seed, length of vine, average length of pod, average number of seeds in pod, average number of pods on vine, weight of pea on six vines, yield of 50 feet of row, and descriptive remarks.

Cabbage (pp. 131, 132).—Notes on sixteen varieties, with table showing from whom purchased, date of marketable maturity, average weight of six heads, shape, color, and condition of heads, etc.

Tomatoes (pp. 133-135).—Notes on thirty-two varieties, with table showing from whom purchased, date of first fruit, date of ripe fruit, length of vine, size, color, and shape of fruit, etc.

Egg plant (p. 136).—Notes on four varieties.

Peppers (pp. 136, 137).—Notes on twelve varieties, with table showing from whom purchased, date of blooming, date of setting of fruit, date of marketable maturity, date of ripening, size of fruit, etc.

Beans (pp. 138-141).—Notes on thirty-five varieties, with tables showing date of blooming, date of end of blooming, date when fit for table, date of ripening of pods, size, shape, and color of seeds, etc.

Musk-melons (pp. 142-144).—Notes on eighteen varieties, with table showing from whom purchased, date of formation of fruit, date of first ripe fruit, average weight of six fruits, size, color, and quality of fruit, etc.

Carrots (pp. 145, 146).—Notes on fourteen varieties, with table showing weight of six roots, date when fit for table, length, color, and smoothness of roots, etc.

Cucumbers (pp. 147, 148).—Notes on thirteen varieties, with table showing from whom purchased, date of setting of fruit, date when fit for table, date of ripe fruit, length, color, and smoothness of fruit, etc.

Sugar beets (p. 149).—Brief notes on four varieties.

Sweet corn (p. 150).—Brief notes on eighteen varieties.

REPORT OF CHEMIST, DAVID O'BRINE, D. Sc. (p. 151).—The total number of analyses made was two hundred and twenty-seven, including analyses of artesian and other waters, cheese, insecticides, apples when blossoms had been sprayed with arsenites, sorghum, sugar beets, alfalfa, bran, and potatoes.

REPORT OF METEOROLOGIST AND IRRIGATION ENGINEER, L. G. CARPENTER, M. S. (pp. 153-221).—The report deals entirely with meteorology. The work includes the testing and controlling of observations and the keeping of current records. Monthly reports have been sent to the Signal Service Office at Washington, and monthly and sometimes weekly reports have been furnished the State weather service. Weekly summaries have also been published in local papers. There are now in the possession of the Station the records of observations extending over several years. In March, 1872, Mr. R. G. Tenny began regular tri-daily observations of the thermometer, and, adding a rain-gauge to his equipment in 1873, carried on the observations until January, 1875. His records were turned over to the college and copied in permanent form.

Shortly after the opening of the college the professor of chemistry began observations of temperature, movements of the wind, and maximum and minimum temperature, and afterward of atmospheric pressure. These observations were continued by various professors until September 1, 1888, when the Station undertook the work. The records are not entirely complete and have as yet been only partially summa-

rized. The observations of soil temperature were also carried on at the college in the summer before the establishment of the Station. Temperatures of the soil at the surface, 6 inches below, and of the air were taken three times each day. These were charted and the chart is on file.

The report contains an illustrated description of the apparatus used at the Station. A table is given showing rain-fall for every month of the years from 1873 to 1888, inclusive, omitting the years 1875 to 1878, inclusive. The average rain-fall for each month of the years recorded is as follows:

Month.	Inches.	Month.	Inches.
January	.86	August	1.04
February	.54	September	.94
March	.69	October	.99
April	1.53	November	.39
May	2.85	December	.34
June	1.67		
July	1.94	Total	13.78

The following table gives the results from experiments in 1887 and 1888 to determine the rate of evaporation from the surface of water in a galvanized iron tank 3 feet square and 3 feet deep, sunk flush with the ground:

Month.	1887.		1888.	
	Total for month.	Rate per day.	Total for month.	Rate per day.
	<i>Inches.</i>	<i>Inch.</i>	<i>Inches.</i>	<i>Inch.</i>
March	4.65	.15		
April	5.55	.185		
May	5.19	.167	4.45	.143
June	5.75	.193	7.70	.257
July	5.23	.17	7.00	.226
August	4.24	.137	4.65	.15
September	4.12	.137	3.35	.11
October	3.26	.105	2.17	.07
November			1.35	.045
December			.99	.032

The report also contains tables showing in detail the record of observations for each month in the year 1888.

The following table shows the amount of sunshine at the Station for eight months of the year 1888, as compared with that of the New York State Experiment Station for the same period:

Month.	New York.	Colorado.
January	14.5	71.5
March	29.7	79.1
July	57.9	69.2
August	56	71.6
September	55	83.2
October	41.8	63.9
November	34.8	60
December	24.2	68.8
Year	39.2	71
That given in the New York record is not the average, but the greatest amount of sunshine in the given month their record shows.		

A table is given showing the actual as compared with the possible amounts of sunshine for each day of the eight months named in the

preceding table. Another table gives a record of soil temperature taken at 7 a. m., 2 p. m., and 9 p. m., at depths of 3 and 6 inches, and 1 2, 3, and 6 feet for each week of 1888, from the middle of June to the end of December.

REPORT OF VETERINARIAN, WM. McEACHRAN, M. D., V. S. (pp. 223-226).—The veterinarian did not begin his work until September 1, 1888, and his report contains only an outline of proposed experiments. These are to include experiments with horses, sheep, and cattle to determine the cause and the nature of the diseases supposed to result from feeding on the loco plant, and the remedies for this disease; experiments with sheep affected with tape-worms, to determine the possible connection of the tape-worm with the cause of the so-called loco disease; to investigate a disease of an unknown nature affecting horses in certain parts of the State, by which they lose their manes and tails.

REPORT OF ASSISTANT HORTICULTURIST IN CHARGE OF THE APIARY, C. M. BROSE (pp. 227-236).—The following table shows the weekly increase in weight of one colony of bees from the 1st of June to the last of September :

Date.	Weight of colony.	Gain per week.	Average gain per day for week.	Average gain per week for season.	Average gain per day for season.	Total gain.
June 2.....	36					
June 9.....	39	3	0.43			
June 16.....	45	6	0.86			
June 23.....	54	9	1.28			
June 30.....	62	8	1.14			
July 7.....	72	10	1.43			
July 14.....	80	8	1.14			
July 21.....	88½	8½	1.23			
July 28.....	98½	10½	1.50			
August 4.....	108¾	10¼	1.46			
August 11.....	130¼	21¼	3.07			
August 18.....	146	15¾	2.25			
August 25.....	155½	9½	1.35			
September 1.....	163¾	8½	1.18			
September 8.....	170¼	7	1.00			
September 15.....	176	5¼	0.75			
September 22.....	176½	½	0.07			
September 29.....	175			8.81	1.26	141

The following table shows the results of experiments with four colonies of bees to determine whether bees can store honey faster in artificial than in the natural comb :

Date.	No. of colony.	Kind of comb.	Commenced storing.	Started in to seal.	Ripe.
June 25. {	9	Artificial.....	July 3.....	July 27...	Aug. 6
	12	do.....	July 5.....	July 25...	Aug. 8
	7	Natural.....	June 28.....	July 30...	Aug. 11
	13	do.....	June 30.....	Aug. 4...	Aug. 15

The table shows that honey made on the artificial comb was ready to be taken off from three to seven days earlier than that made on the natural, although the bees began storing in the natural sooner than in

the artificial. The report gives an account of the successful introduction of two Italian queen bees into the swarms of common bees.

An experiment in feeding the colony of bees with a sirup containing the same proportion of London purple and Paris green as a mixture sprayed on fruit trees showed that while the mixture was poisonous to the bees it did not affect the honey stored by the bees which fed upon the poisonous sirup.

REPORT OF THE SAN LUIS VALLEY STATION, H. H. GRIFFIN, B. S. (pp. 237, 238).—This report is a mere outline of work undertaken to prepare the station farm for field experiments of the next season.

REPORT OF THE BENT STATION, FRANK WATROUS (pp. 239-242).—The report contains an account of the location of the Station, and the soil and general condition of the station farm, and also an outline of proposed field experiments. The farm is located $1\frac{1}{4}$ miles from Rocky Ford, and comprises 200 acres, 160 acres of which is unbroken sod. The farm dips slightly to the north and east, and from nearly every point water may run in two directions without serious impediment. The Station is 75 miles from the mountains, near the Arkansas River, in latitude 38 degrees, at an altitude of 4,000 feet. The climate is one of meager rain-fall and light winds, with frequent winds in the spring and fall, occasional hot winds in summer, and long periods of clear, warm weather, causing very rapid diminution of moisture from the soil and atmosphere. Irrigation is necessary to successful agriculture in this region.

The soil is of an alluvial nature, somewhat largely composed of an admixture of fine sand and clay, known as adobe, usually rather light; in most cases, without any hardpan immediately below surface soil. In other places on the same tract will be found a solid clay hardpan. The top soil on all land belonging to the Station is light and sandy, and, with the exception of a few spots having hardpan as mentioned above, the soil is porous and easily permeable to a depth of at least ten feet below the surface, showing that surface moisture will be diminished rapidly both from above by evaporation and from below by percolation, a further indication of the necessity of a plentiful water supply for frequent irrigation, while, in addition, it is evident from the uniform slope of the land and the depth of porous soil, that a very small portion, if any, of the farm will stand in need of drainage.

During the process of irrigation, owing to the fact that the Arkansas River water is heavily laden with particles of soil, a heavy deposit of sediment is given to the soil, and if undisturbed this deposit settles very compactly, becoming when dry quite hard and almost impenetrable to vegetable growth.

To so distribute water in irrigation that this sedimentary deposit will not choke out or seriously impede plants in their growth, and to cultivate in such time and manner that this alluvial matter may be assimilated in the soil and become an enriching constituent thereto, will be not the least important matter for consideration at this Station.

REPORT OF THE SPECIAL COMMITTEE APPOINTED BY THE STATE BOARD OF AGRICULTURE TO EXAMINE THE WORK OF THE STATION (pp. 243-245).—The committee was composed of one representative from each of the following associations: Colorado Cattle Growers' Association, State Horticultural Society, and State Grange. Their report commends the work of the Station.

CONNECTICUT.

The Connecticut Agricultural Experiment Station.

Location, New Haven.

Director, Samuel W. Johnson, M. A.

ANNUAL REPORT FOR 1888.

[To meet the requirements of the State law, the demands of the public, and the exigencies of Station work in the best manner, it has been found advisable to publish the report in two parts at different times. Both parts are united in one and published, with the Report of the Storrs School Station, in the same volume with the Report of the State Board of Agriculture.]

REPORT OF BOARD OF CONTROL, W. H. BREWER, SECRETARY (pp. 1-7).—The report contains the act of the legislature, approved May 18, 1887, assenting to the act of Congress of March 2, 1887. The Station receives one-half of the annual appropriation of \$15,000, the other half being given to the Storrs School Station. With the increase of its revenue a department was established for the investigation of the Fungous Diseases of Plants, more especially those diseases which affect the crops of the State. A new laboratory was built for this department, and Dr. Roland Thaxter, late instructor in Mycology at Harvard University, was appointed mycologist.

At the annual meeting of the Board, in January, the methods of collecting fertilizers were fully discussed. That the farmers and gardeners should know just what commercial fertilizers are offered for sale in the State is evident, and justice to the reputable dealers demands that the collection should be as complete and thorough as possible. The method pursued in 1887 was considered better than any before tried, and it was recommended to continue the same. It is believed that the collection has been more successfully done this year than ever before.

REPORT OF DIRECTOR (pp. 9-87).

Number of analyses made.

Commercial fertilizers (one for each kind legally sold in State)	140
Home-mixed fertilizers and waste products	104
Feeding-stuffs.....	130
Samples of potatoes.....	14
Samples of butter.....	11
Samples of molasses.....	50
Samples of honey.....	11
Milk (to test methods of analysis) about	30
Total	490

A portion of the above analyses were made in behalf of the State Dairy Commission.

Ten co-operative field experiments were performed by farmers in different parts of the State with phosphates on Indian corn and potatoes and on the effect of distance of planting on the quantity and quality of the maize crop, and one experiment on the growth of sorghum.

Besides the Annual Report, in two parts at different times, two Bul-

letins were published in editions of 5,000 copies. A part of each edition was sent in bulk to postmasters for distribution among farmers.

The Station has also issued five Weekly Statements, printed in a very limited edition by the hektograph process, and supplied as far as possible to the agricultural press and to secretaries of farmers' clubs and agricultural societies.

Connecticut fertilizer law.—The following is an abstract of the main provisions of the law passed in 1882. (For full text with explanatory notes, see Report, pp. 14–16.)

(1) In case of fertilizers that retail at \$10 or more per ton, the law holds the seller responsible for affixing a correct label or statement to every package or lot sold or offered, as well as for the payment of an analysis fee of \$10 for each fertilizing ingredient which the fertilizer contains, or is claimed to contain, unless the manufacturer or importer shall have provided labels or statements and shall have paid the fee. (Sections 1 and 3.)

(2) The law also requires, in case of any fertilizer selling at \$10 or more per ton, that a certified statement of composition, net weight in package, etc., shall be filed with the Director of the Experiment Station, and that a sealed sample shall be deposited with him by the manufacturer or importer. (Section 2.)

(3) It is also provided that every person in the State, who sells any commercial fertilizer of whatever kind or price, shall annually report certain facts to the Director of the Experiment Station, and on demand of the latter, shall deliver a sample for analysis.

(4) All "chemicals" that are applied to land, such as muriate of potash, kainit, sulphate of potash and magnesia, sulphate of lime (gypsum or land plaster), sulphate of ammonia, nitrate of potash, nitrate of soda, etc., are considered to come under the law of "commercial fertilizers." Dealers in these chemicals must see that packages are suitably labeled. They must also report them to the Station, and see that the analysis fees are duly paid, in order that the Director may be able to discharge his duty as prescribed in section 9 of the act.

Analyses of fertilizers (pp. 21–81).—The Station makes two classes of analyses of fertilizers and fertilizing materials: (1) Without charge, for the benefit of farmers, gardeners, and the general public; (2) at moderate rates for the private use of manufacturers and dealers. The gratuitous analyses for public use are made from samples either collected by the agents of the Station or sent by other parties, in accordance with specified regulations.

During 1888 two hundred and forty-four samples of fertilizers have been analyzed. Of these, a small number were examined for private parties and for testing methods in connection with other Experiment Stations, and the remainder for the general use of the citizens of the State.

During April and May last the agents of this Station have collected samples of commercial fertilizers in all parts of Connecticut; one hundred and forty-four towns and villages have been visited and eight hundred and eighty-seven samples were taken by these gentlemen, who employed the method of sampling which is described on page 91 of the Report of this Station for 1884. * * * In this way one or more samples were secured of nearly every brand of fertilizer which is offered for sale within the State. When several samples of a single brand were drawn in different parts of the State the analysis was performed, not on any single sample, but on a mixture made of an equal weight of each of the several samples. Thus, it is believed, the average composition of the goods is more fairly represented than by the analysis of single samples.

The Station agents are instructed, when drawing samples, in every case to open at

least three packages of each brand, and if the number of packages is large, to take a portion from every tenth one, by means of a sampling tube, which withdraws a section or core through the entire length of the bag or barrel.

Instructions for sampling commercial fertilizers.—(1) Provide a teacup, some large papers, and for each sample a glass fruit-can or tin box holding about 1 quart that can be tightly closed, all to be clean and dry.

(2) Open at least three full and unbroken packages, or, if there are more than thirty, every tenth package, and mix well together the contents of each for a foot in depth; take out two cupfuls from different parts of the mixed portions of each package, pour them [six in all] over one another upon a paper, intermix thoroughly but quickly to avoid gain or loss of moisture, fill the can or box from this mixture, close tightly, fix securely on the outside of the can a label with some distinguishing letter or mark (which is to be copied in the "Description of Sample" as *sampler's mark*), and send prepaid to the Agricultural Experiment Station, New Haven, Conn.

(3) If convenient weigh separately at least three packages and enter these *actual weights* in the "Description of Sample."

(4) When a sample has been taken it should *always* be bottled, labeled, and the form for its description filled out completely *before* beginning to sample another fertilizer.

Further remarks on sampling.—In case of a fine, uniform, and moist or coherent article, a butter trier, or a tin tube, like a dipper handle, put well down into the packages in several places, will give a fair sample with great ease.

With dry, coarse articles, such as ground bone, there is liable to be a separation of coarse and fine parts on handling. Moist articles put up in bags or common barrels may become dry on the outside. It is in these cases absolutely necessary to mix thoroughly the coarse and fine, the dry and the moist portions, before sampling.

The quantity sent should not be too small. When the material is fine and uniform, a pint is enough, but otherwise, and especially in the case of ground bone, which must be mechanically analyzed, the sample should not be less than one quart.

It is important that samples for analysis should be taken at the time when the fertilizer is purchased, and immediately dispatched to the Station.

Forms for description and certificates to accompany samples, and other details and regulations, are given. The attempt is made to insure protection of the interest of both buyer and seller, and to secure the co-operation of farmers, both as individuals and as organizations.

Results of comparisons—analyses, with selling prices.

	Number of analyses.	Cost per pound in cents.
Nitrogen:*		
From cotton-seed meal.....	7	11.9 to 13.4
From castor pomace.....	2	13.9 to 14.4
From nitrate of soda.....	2	15.4 to 15.9
From sulphate of ammonia.....	4	17.5 to 17.9
Phosphoric acid:		
From Thomas-slag and native phosphates.....	4	2.8 to 4.3
From dissolved bone-black.....	4	7.9 to 8.2
Potash:		
From muriate of potash.....	6	3.9 to 4.2
From sulphate of potash.....	3	5.4 to 6.1
From cotton-hull ashes.....	2	4.5 to 5.2

*The cheapest source of available nitrogen during the last season has been cotton-seed meal.

Difference between cost and valuation.—Leaving out of account one analysis in which the cost exceeded valuation by more than 50 per cent, the average cost of sixty-eight nitrogenous superphosphates was \$34.55, and the average valuation \$28.70. The difference is \$5.85, and the percentage difference 20.3.

That is, the same quantities of nitrogen, phosphoric acid, and potash, which were contained in an average ton of nitrogenous superphosphate, could have been bought in raw materials of standard quality in ton lots in this State for \$28.70 cash; in the average superphosphate they cost \$34.55, and hence the manufacturers' and dealers' expenses and profits on a ton of fertilizer averaged \$5.85, or 20.3 per cent of the cost of the materials.

Guarantees.—The analyses of twenty-one superphosphates out of the sixty-nine show that their composition is below the minimum guarantee in one or more particulars. Fourteen are deficient in one ingredient, six in two, and one in three ingredients. In most cases the deficiency is due to a misleading, and in this State illegal, method of expressing the guarantee of potash. It is required, under the law, that the quantity of *actual* potash shall be expressly stated. "Potash, sulphate, 4 per cent" means 4 per cent of *actual potash* in the form of sulphate, and not 2.16 per cent of potash.

Fish and potash.—The analyses of this material, which has been a favorite fertilizer in this State, though tabulated with the nitrogenous superphosphates are also tabulated by themselves on page 63. Most of the brands are not simple mixtures of fish scrap and potash salts, as the name would imply, but contain other phosphates and in one case much insoluble phosphate.

*Special manures sampled by station agents.**—Here are included such nitrogenous superphosphates as are claimed by their manufacturers to be specially adapted to the needs of particular crops. In previous reports the justice of such claims has been discussed.

Guarantees.—Nine samples are below guarantee on one ingredient and two samples on two ingredients, making a third of the whole number which fail to come up to their minimum guarantee.

Cost and valuation.—The average cost of the special manures has been \$39.47, and the average valuation \$33.99. The difference between cost and valuation is \$5.48 and the percentage difference 16.1. The corresponding difference in case of the superphosphates (see page 49) was 20.3 per cent. This year, as heretofore, the special manures as a class have been higher-priced than the other nitrogenous superphosphates, more concentrated, and if the quality of the raw materials composing them is equally good, more economical to purchase.

	Average cost per ton.	Average valuation per ton.	No. of analy- ses.
Bone manures.....	\$32.80	\$39.07	22
Bone and potash.....	40.00	40.41	1
Tankage (offal collecting on the bottom of tanks, in which grease is separated from the waste of slaughter-houses).....	{ 29.60 to 35.00	{ 21.16 to 38.32	{ 6
Nitrogenous superphosphates (the dealer's and manufacturer's profit therefrom averaged \$5.85 per ton, or 20.3 per cent.).....	34.55	28.70	68
Special manures (including nitrogenous superphosphates claimed by manufacturers to be adapted to particular crops).....	39.47	33.99	.....

* For tables of analyses, etc., see pages 66-72.

Home-made mixtures (cost per ton of unmixed materials \$32.41 to \$38.49).—Examination of the samples and of the table of analyses shows—

(1) That these home mixtures compare favorably in composition with the best commercial fertilizers. In all cases but one the valuation is higher than the average valuation of factory-made superphosphates or specials analyzed last year.

(2) The home mixtures are not as finely ground as the *best* factory-made fertilizers, yet their mechanical condition is satisfactory.

(3) In only one case does cost of materials exceed valuation. If we add \$3 per ton for cost of mixing, the valuation and the cost will be about the same. The cost of factory-made fertilizers usually exceeds valuation by 20 to 25 per cent.

These analyses justify the statement made in the last report, that while it is often cheaper to buy the best commercial mixtures—ammoniated superphosphates and special manures—than to buy and mix the chemicals, yet the experience of a yearly increasing number of farmers shows that money may be saved by the seasonable purchase of raw materials and their use in home mixtures.

We call the attention of those who intend to purchase raw materials the coming season and do their own mixing to the following suggestions:

(1) As has already been noted, soluble phosphoric acid should cost considerably less in the form of dissolved South Carolina rock than in dissolved bone-black. Thus in New Jersey soluble phosphoric acid has cost about 6.2 cents per pound the present season in dissolved South Carolina rock, while it has cost 7½ cents in dissolved bone-black. The Carolina rock yields a lower-grade article than bone-black, averaging in composition about as follows:

Dissolved South Carolina rock.

Soluble phosphoric acid.....	9.9
Reverted phosphoric acid	1.7
Insoluble phosphoric acid	3.6
Total phosphoric acid.....	15.2

Besides superphosphates, there are other sources of phosphoric acid which are well worth the attention of buyers of raw materials. Thomas-slag has been used with success abroad, and field experiments made for this station in this State have in certain cases at least given very satisfactory results. [The outcome of this year's experiments will be found in the latter part of this report.] Fine ground bone containing from 24 to 30 per cent of phosphoric acid from 1.5 to 4 per cent of nitrogen can be got for from \$26 to \$32 per ton, while bone-black superphosphate, containing 17 per cent of phosphoric acid and a small fraction of 1 per cent of nitrogen, costs \$26.

(2) This year the cheapest sources of organic nitrogen have been castor pomace at \$20 per ton and cotton-seed meal at \$25. While nitrogen in blood, tankage, and fish costs from 16 to 17 cents per pound, in castor pomace and cotton-seed meal it costs only 12 to 14 cents. Occasionally car lots of cotton-seed meal are offered at even lower rates because damaged and "off color." If the dark meal is not moldy or damp, its value *as a fertilizer* is probably not less than that of the prime quality meal. Of course it is unsafe to use as a *cattle food* any but the best quality of meal. There is good reason to believe that the nitrogen of these vegetable products is equally efficacious as plant food with that of animal matter, and therefore it would be well to consider these materials in purchasing nitrogen. Their composition is given on page 35.

(3) There should always be a clear understanding between the purchasers and sellers of fertilizing chemicals as to their guaranteed quality. We reprint, for the information of those interested, a form taken with slight alterations from a circular sent to dealers in fertilizing chemicals by a New Jersey grange, which may be convenient for use by granges and farmers' clubs in this State :

Wanted, to buy, the materials to make — tons or more of fertilizer; the materials to consist of nitrate of soda, sulphate of ammonia, acid phosphate, dissolved bone or bone-black, fine-ground bone, fine-ground fish scrap, muriate of potash, and sulphate of potash.

All materials to be in good mechanical condition; in good bags; to run even weights or to be plainly marked what each bag contains net, and to be delivered at —, early in March next. All materials to be guaranteed to contain certain percentages of nitrogen, potash, or available phosphoric acid, as the case may be; one-half of the bill to be paid within ten days after receipt of goods; on the other half a credit of sixty days to be allowed, within which time samples will be sent to the Connecticut Experiment Station for analysis, and if there found to contain as large percentages as guaranteed the balance of the bill will be paid within the sixty days, but if any are found to contain a less percentage than guaranteed, then a discount is to be allowed on the bill equal to the loss in money value caused by such deficiency for the first 1 per cent or fraction thereof, and twice the loss in money value for all deficiencies in excess of 1 per cent, and balance of bill within the sixty days. Samples to be taken by a station agent or other disinterested party.

Hen manure.—Numerous analyses of “hen manure” have been made at this Station, but the material has always been a mixture of hen-dung with variable quantities of feathers, straw, and earth, scraped from the floor of the hennery. We have no analyses of the unmixed hen-dung. The difference between the excrement of fowls and that of cattle of all sorts is, that the former contains in solid form all the fertilizing material of the food except what is retained in the body for growth or goes into the eggs; while a very considerable portion of the fertilizing value of the food of cattle is excreted in liquid form, and is easily lost even in the stalls or barn-yard. It is easy to see, then, why the dung of fowls is a richer manure than that of cattle. That of the former contains both the urinary and bowel excretions; that of the latter consists largely of the undigested food, with what of the urine may have been absorbed and retained by it.

THE COMPOSITION OF AMERICAN FEEDING STUFFS, E. H. JENKINS, PH. D. (pp. 89-94):

On these pages is given in tabular form the average composition of the feeding stuffs commonly used in this country, compiled exclusively from American analyses. In the first column of these tables is stated the total number of analyses from which the average was obtained. The probable accuracy of the average increases with the number of analyses on which it is based.

As it is very desirable to know within what limits the composition of each fodder is likely to vary, the maximum and minimum amounts of each ingredient have also been inserted in the table.

The wide differences of composition which appear in some cases are no doubt largely due to differences in the methods of analysis followed. It is extremely important that there should be uniformity in this respect, and it is hoped that the methods recommended by the Association of Official Agricultural Chemists may be adopted by all who engage in agricultural chemical analysis.

Analyses of feeding stuffs made at this Station during the present year will be found farther on in the report.

As Dr. Jenkins is making an extended compilation of results of analyses of American feeding stuffs for publication by the Office of Experiment Stations of the United States Department of Agriculture, none of the tables above referred to are reproduced here.

CONNECTICUT GRASSES (pp. 95-104).—Hay and pasture are among

the most important factors of Connecticut farming. The work being done upon this subject is thus explained:

In the last report the improvement of our meadows and pastures was spoken of as one great need of our agriculture. A better knowledge of our pasture and meadow grasses, their habits and uses, is a first step toward supplying this need. Questions as to the adaptation of different grasses to particular kinds of soil, the necessary water supply, their rooting habits, how they stand treading and close pasturing by cattle, causes of running out, etc., are still unsettled and show how much must be learned before we can manage grass land to the best advantage. Near our cities the hay crop is sometimes the most profitable one we have, and might often be made much more so by proper management. Our common grasses ought to be known, so that they can be readily told apart by farmers generally at all seasons of the year and rightly named, for till this is done it is clear that no one can speak or write about grasses with any chance of being understood. In the last report were some explanations of the classification and naming of grasses and an explanatory list of the scientific and popular names of our commonest Connecticut grasses. There was also some account of the station forage garden, in which are to be seen all our common grasses growing, correctly named, and where their habits can be studied to some extent and where pure seed can be got. Extra copies of this part of the report can be supplied to any who want them.

During the present year there has been shown a greatly increased interest in this subject throughout the State. More than a hundred and fifty specimens have been sent in to be named or for other information from all parts of the State. Named specimens of fresh grasses have also been sent out by the Station in answer to requests for them. The Station is prepared to identify specimens of grass sent here, and so far as possible will supply collections of small samples of seed to any schools, granges, or farmers' clubs that would like to have a collection of named grasses growing near them.

Should sufficient interest be awakened, we could perhaps arrange to send by mail whole plants for inspection and study as they come into bloom through the season.

The Station is also always prepared to examine for farmers seeds of grasses or of vegetables with reference to their purity and vitality.

It is especially desired that any prevalent disease on grasses, such as mildew, rust, etc., and particularly ergot, which has sometimes done great injury at the west in wet seasons, may be brought to the attention of the Station.

A list of the botanical names of the one hundred and fifty-seven grasses and other forage plants grown in the station forage garden is given, with brief notes on some grasses not commonly grown in Connecticut. Tables are given which show the results of first year's analyses of common meadow grasses, made to determine whether under the same treatment these grasses would show decided and constant differences in composition.

CHEMICAL WORK FOR STATE DAIRY COMMISSIONER (pp. 105-111).

Examination of butter (p. 105).—On page 133 of our report for 1886 the chemical methods of examination are given in detail. The method of determining volatile fatty acids has been somewhat modified in view of recent investigations made abroad. The fat is saponified in a closed flask, with potassium hydrate solution (free from carbonates), without the addition of alcohol. Barium hydrate is used for the subsequent titration. Otherwise the method now used by us is the same as there described.

Since that report forty-five samples of suspected butter have been examined for the commissioner, of which thirty-five were imitation butter. The specific gravity of the imitation butter, determined as described in our report for 1886, varied between

.8583 and .862. The volatile fatty acids in 2.5 grams of filtered fat expressed in cubic centimeters of one-tenth normal potassium hydrate solution varied between 0.5 and 6.4. A single sample of genuine butter had the exceptionally low specific gravity of .8625. The others varied between .8644 and .8666. The volatile acids varied between 12.82 and 16.81.

Examination of molasses (pp. 105–108).—Of twenty-two samples analyzed soon after the passage of a State law against the adulteration of molasses, nine contained glucose; one also contained salts of tin. But after public notice that sellers of adulterated molasses would be prosecuted all the samples analyzed proved to be pure molasses.

Method of examination of molasses.—The method followed has been to polarize the molasses directly, after clearing with basic lead acetate, polarize after inversion according to Clerget's method at ordinary temperature, and polarize a third time at a temperature of about 88° C.

No attempt has been made to calculate the sugar on account of the difficulty and uncertainty of the work, and also because it is not necessary to a correct judgment of the genuineness of the molasses. Genuine molasses will show from about 38 to 55 per cent "polarization sugar" by direct polarization; after inversion with an acid, a polarization of from 10 to 18 or 20 scale degrees to the left in the Scheibler instrument at ordinary temperatures and from 0 to + 5 or 6 degrees at 88° C.

Molasses adulterated with glucose almost always shows over 75 per cent "polarization sugar" by direct polarization, which at once proves the adulteration, for molasses does not contain more than that quantity of solids altogether.

After inversion the rotation is still right-handed, though less than before. The rotatory power of dextrose ("glucose") is not changed by the acid used for inversion; dextrine and maltrose, (?) however, which are in the glucose sirup, have their right-handed polarization somewhat lessened by the action of the acid, and of course the cane sugar present is changed to invert sugar, which polarizes to the left. Nevertheless the polarization of the whole mixture is still strongly to the right.

Next, when the temperature is raised to about 86° C. the polarization of molasses mixed with glucose sirup, instead of sinking to within a few degrees of zero, remains about where it was before, rising or falling slightly according to the relative amounts of dextrine and of invert sugar in it. * * * The polarizations were made with Schmidt and Haensch's double compensation, half-shade instrument. * * * The readings after inversion are corrected for dilution.

Examination of honey (pp. 108–111).—The analyses of honey made at the Station show that adulteration will not pay unless so large as to be almost certainly detected by chemical analysis. A tabular statement is given of analyses of honey from different sources, *e. g.*, "from flowers and fruits, sent in the comb;" "from basswood bloom, liquid, strained;" "same as last, but granulated;" and from dealers in different brands, as "choice clover honey;" "superior new honey;" "pure northern honey," etc.

Methods of examination—Specific gravity.—Owing to the viscosity of honey, the method of Lenz was used. One part of honey and two of distilled water are accurately weighed and mixed and the specific gravity of the mixture is observed at 17° C. For this we have made use of the Westphal balance.

Copper-reducing power.—A solution of 5 grams of honey in water is made up to 500 cubic centimeters, and in 25 cubic centimeters of the solution the reducing power determined by Allihn's method and expressed as dextrose. It is well understood that a considerable part of the sugar of honey is invert sugar which consists of equal parts of dextrose and lævulose, which have towards Fehling's solution a somewhat different reducing power. But there is at present no satisfactory method of sepa-

rately determining the two sugars, so the above purely arbitrary method of expressing the reducing power was adopted.

Copper-reducing power after inversion.—A solution of 5 grams of honey in water is made up to 200 cubic centimeters; 20 cubic centimeters of pure concentrated hydrochloric acid are added and thoroughly mixed, and the whole is kept at a temperature of 68° to 70° C. for fifteen minutes. After cooling, the free acid is nearly neutralized with sodium hydrate, the solution is made up to 500 cubic centimeters, and in 25 cubic centimeters the copper-reducing power is determined as above.

The difference between the copper reduced after inversion and that reduced before inversion is expressed as cane sugar.

Method of polarization.—13.024 grams of honey (or one-half the normal quantity for the polariscope used) are dissolved in water, 3 cubic centimeters of basic lead acetate are added, then 2 cubic centimeters of a saturated solution sodium carbonate and water to make exactly 100 cubic centimeters.

The solution, passed through a dry filter, is examined in a 200-millimeter tube in the polariscope. The reading is multiplied by two to represent the polarization of the normal quantity of honey.

To 50 cubic centimeters of the above solution are added 5 cubic centimeters of pure concentrated hydrochloric acid, and the mixture is heated at 68° to 70° C. in a corked flask for fifteen minutes. After cooling, the temperature and the rotation in a 220-millimeter tube are observed, and the reading multiplied by two as before. The tube, without being removed from the polariscope, is now heated to about 86° C., and the rotation is again observed and corrected as before.

Ash.—Five grams of honey are dried and ignited at a low heat in a weighed platinum dish.

CO-OPERATIVE FIELD EXPERIMENTS WITH FERTILIZERS (pp. 112-140).—Connecticut farmers pay over \$200,000 per year for phosphoric acid in commercial fertilizers. It costs them from 3 to 8 cents per pound in standard materials. What forms are most economical is an important matter, and one which can be best tested by practical tests in the field. An account of experiments made under direction of the Station by a number of farmers on their own farms in different parts of the State commences thus:

The cost of phosphoric acid in fertilizers varies greatly according to the material in which it is purchased. Thus in superphosphates prepared from bone-black it costs at present about 8 cents a pound, in dissolved South Carolina rock between 5 and 6 cents, in Bolivian guano a little over 4 cents, and in Grand Cayman's phosphate and ground South Carolina rock about 3 cents. Without doubt the more expensive superphosphates applied in moderate quantity will generally make a larger yield on land deficient in phosphoric acid than the same quantity of the cheaper raw phosphates or natural phosphates, as they are called. But since almost three times as much phosphoric acid can be bought for the same money in raw phosphates as in superphosphates, it becomes a very practical question whether their prices stand in close relation to their agricultural value; whether for some crops instead of using a small quantity of superphosphate it may not pay to use a larger quantity of some other less soluble phosphate which costs less per pound. Last year a single experiment on this point was carried out with the assistance of Mr. W. I. Bartholomew, of Putnam. The same experiment substantially has been repeated this year with the co-operation of nine gentlemen.

The general plan of experiment was as follows: Land was in all cases selected which in the judgment of its owner was uniform in quality, which had all been cultivated alike, and which had not been manured for some years. Only on such land could it be expected that one plat would give the same yield as another plat similarly treated, and that a fertilizer would considerably increase the yield. Over the whole experi-

mental field was broadcast a liberal quantity of nitrogenous matter and potash salts—more than sufficient for a maximum crop. This was essential in order that the yield should be limited by the quantity of phosphoric acid in the soil and not by either nitrogen or potash. The field was then divided into seven or more plats, which were designated by letters, A, B, C, etc., and on which the different phosphates were applied. The phosphates chosen for comparison were: (1) Dissolved bone-black, containing 16.53 per cent of phosphoric acid; (2) a finely pulverized phosphatic rock, from Grand Cayman Island, in the Caribbean Sea, containing considerable iron and alumina with 26.22 per cent of phosphoric acid; (3) Thomas-slag, a by-product of the steel manufacture, containing 19.6 per cent of phosphoric acid; (4) ground South Carolina rock, containing 25.5 per cent of phosphoric acid; (5) Bolivian guano, a phosphatic guano from the West Indies, containing 17.2 per cent of phosphoric acid.

On the first plat a quantity of dissolved bone-black was used, which it was believed would insure a fair yield and yet would not be in excess of the needs of a full crop, but rather slightly deficient.

A single plat was given to each of the other phosphates, and they were used in such quantity that the cost of each was just equal to the cost of the dissolved bone-black on the first plat. Two or more plats received no phosphate and thus served to show the natural capacity of the soil itself to supply phosphoric acid to the crop.

The land was planted and cultivated as usual, and the weight of the crop at harvest was taken in almost all cases by a representative of the Station.

Mr. Bartholomew has conducted four experiments: one with Indian corn, begun in 1887 and repeated in 1888, but without application of phosphates the second season, in order to test the after effects of the phosphate applied in 1887; another experiment with corn, in 1888, and two experiments with potatoes, in 1888. All were in the same field. The experiments with potatoes are thus described:

One was on land where rye grew in 1887, the other on land which was mowed in that year. In each there were seven plats, 5 rods long and 2 rods wide, making one-sixteenth of an acre in each plat.

Over each half acre were broadcast 240 pounds double sulphate of potash and magnesia and 80 pounds of sulphate of ammonia.

At planting, the following quantities of phosphates were applied to the plats in each experiment:

A, 29 pounds dissolved bone-black.	E, 43.3 pounds ground South Carolina
B, 29 pounds Grand Cayman's phosphate.	rock.
C, No phosphate.	F, No phosphate.
D, 34.6 pounds Thomas-slag.	G, 34.7 pounds Bolivian guano.

The following table gives the results of the experiments:

Weight of potatoes in Mr. Bartholomew's experiment with phosphates.

Phosphates applied.	Experiment II.—Planted after rye.			Experiment III.—Planted on meadow land.		
	Large.	Small.	Total.	Large.	Small.	Total.
A, Dissolved bone-black	620	125	745	665	130	795
B, Grand Cayman's phosphate	618	120	738	557	144	701
C, No phosphate	475	120	595	550	88	638
D, Thomas-slag	585	165	750	559	150	709
E, South Carolina rock	462	130	592	570	120	690
F, No phosphate	480	105	585	495	150	645
G, Bolivian guano	540	136	676	491	105	596

The agreement between the plats C and F, which received no phosphate, in respect to yield is close enough to make it probable that the land was fairly uniform in quality.

If the average total yield of plats C and F is taken as 100 per cent, the comparative yield on the other plats is as follows:

	On rye land.	On meadow land.
C and F, No phosphate	100	100
A, Dissolved bone-black	126	124
B, Grand Cayman's phosphate	125	109
D, Thomas-slag	127	110
E, Ground South Carolina rock	100	108
G, Bolivian guano	114	93

Results.—The striking result of these experiments is that on the rye land both Grand Cayman's phosphate and Thomas-slag produced as large an increase over the no-phosphate plats as did dissolved bone-black. Bolivian guano only gave half as much increase, and ground South Carolina rock produced no increase at all.

But on inverted sod, while dissolved bone-black gave the same increase as on the rye land, Grand Cayman's phosphate and Thomas-slag gave very much less. South Carolina rock gave as large an increase as these, while the Bolivian guano yielded actually less than the plats to which no phosphate was applied.

One more experiment will suffice to indicate the general character of the whole work.

Experiment with corn carried out by Mr. W. H. Yeomans, Columbia.—The general arrangement of the experiment was the same as has already been described. Muriate of potash was applied at the rate of 320 pounds and sulphate of ammonia at the rate of 200 pounds per acre. The separate plats contained each one-sixteenth of an acre. The quantities of phosphate applied are given in the following table; the money value of the phosphate applied to each plat was the same.

Mr. Yeomans's notes supply all other details and are as follows:

May 8. Plowed the ground—a yellow, gravelly loam, with a clayey subsoil—that had been cropped with buckwheat the season before, being dressed with a superphosphate at the rate of 150 pounds per acre; previous to that had been in pasturage for a good number of years. At the time of plowing the soil was in good condition, but the next day it came on wet, continuing until the 10th, when, after raining through the night, the weather improved.

May 22. The sulphate of ammonia and muriate of potash were sown on and harrowed in. The phosphates were put in the hill. Commenced planting the corn in the afternoon and finished on the 23d, with warm and pleasant weather and the ground in fine condition. From the 24th the weather continued cloudy and misty, with showers of rain until June 1, with the exception of May 30, when there was some sun.

June 1. The corn commenced to come up; that planted on the Thomas-slag presenting the best appearance.

June 13. Commenced hoeing the first time in the afternoon, finishing the forenoon of the 14th. At this time A and H presented an appearance of superiority, the other plats showing no distinctive difference.

June 21. A and H making rapid growth, with H leading. G but little better, if any, than C and F.

June 26. Commenced hoeing the second time in the afternoon, finishing in the forenoon of the 27th. A and H looking finely, showing less difference, while all the other plats continue backward.

During July the plats B, D, E, and G, showed quite a little improvement, and on August 1, when A and H had commenced the development of ears, these exhibited no tendency to earing, but as the season advanced ear-formation commenced.

September 19. A and H well advanced in ripening. B appears quite fair in earing. D, E, G, have made some ears, while C and F are very light. At the time of planting each plat consisted of five rows of fifty-five hills in each row, or two hundred and seventy-five hills in each plat; and to provide against loss from failure to germinate and from worms or usual depredations and have a stand of four stalks in each hill,

six kernels were planted in each hill. It germinated unusually well, but cut-worms made considerable havoc with it during the early growth. By the six kernels each plat should have had 1,650 stalks, and allowing for a reduction of four in each hill upon an average, there should have been 1,100 stalks.

The stalks in the several plats were counted carefully, giving the following result:

Plats.	No. of stalks.	Stand.*
A.....	991	— 109
B.....	1073	— 27
C.....	919	— 181
D.....	1122	+ 22
E.....	1008	— 92
F.....	985	— 115
G.....	852	— 248
H.....	979	— 121

* More (+) or less (—) than a full stand.

September 25. The corn was cut and placed in stacks, had not been affected by frost, and was in good condition.

November 15. Corn husked and stalks weighed. The stalks on A and H were much the largest, these on H being larger than those on A, a feature which was marked during a considerable period of the growth. On husking, the corn on A had more sound, smaller, and compact ears than was the case with H, where the ears grew somewhat longer but only one upon a stalk, while many of the stalks of A had two ears each.

The results of the experiment are given in the following tables:

Actual weights of crops as harvested.

	Stover.	Sound ears.	Soft ears.	Total ears.
A, 16 pounds dissolved bone-black	211	198	21 $\frac{3}{4}$	219 $\frac{3}{4}$
B, 23 pounds Grand Cayman's phosphate.....	133	76 $\frac{1}{2}$	54 $\frac{1}{2}$	131
C, No phosphate	78	2	34 $\frac{1}{2}$	36 $\frac{1}{2}$
D, 27 $\frac{1}{2}$ pounds Thomas-slag	118	34 $\frac{3}{4}$	58	92 $\frac{3}{4}$
E, 34 $\frac{1}{2}$ pounds ground South Carolina rock	106	18 $\frac{1}{2}$	57	75 $\frac{1}{2}$
F, No phosphate	69	5 $\frac{1}{2}$	32 $\frac{1}{2}$	37 $\frac{1}{2}$
G, 27 $\frac{1}{2}$ pounds Bolivian guano.....	102	23 $\frac{3}{4}$	41	64 $\frac{3}{4}$
H, 32 pounds dissolved bone-black.....	293	179	31 $\frac{3}{4}$	210 $\frac{3}{4}$

These results have been re-calculated in the next table to a full stand of corn in this way: Plat A had 991 stalks on it, which yielded 211 pounds of stover. A full stand would have been 1,100 stalks. If 991 stalks yielded 211 pounds of stover, 1,100

stalks would have yielded $\frac{211 \times 1100}{991} = 234.1$ pounds.

Weights of crops, making allowance for missing stalks.

	Stover.	Sound ears.	Soft ears.	Total ears.	Total crop.
A, Dissolved bone-black	234.1	219.8	24.1	243.9	478.0
B, Grand Cayman's phosphate	136.3	78.4	55.8	134.2	270.5
C, No phosphate	93.3	2.4	41.3	43.7	137.0
D, Thomas-slag.....	115.6	34.0	56.8	90.8	206.4
E, Ground South Carolina rock	115.6	20.2	62.0	82.2	197.8
F, No phosphate	76.9	5.9	36.5	42.4	119.3
G, Bolivian guano	131.6	30.7	52.9	83.6	215.2
H, Double quantity dissolved bone-black	329.2	201.1	35.6	236.7	565.9

It appears in the first place that Mr. Yeomans's field was naturally poor in assimilable phosphoric acid, and in this regard was suitable for the experiment. A moderate

application of dissolved bone-black produced a threefold increase of total crop and a fivefold increase of ears.

It also appears that the land was tolerably uniform in quality, so that it is fair to assume that the differences in the yield of the plats were mainly due to differences in the effect of the phosphates, not largely to differences of soil.

Thus the two plats which received no phosphates produced 43.7 and 42.4 pounds of ears and 93.3 and 76.9 pounds of stover, respectively. Again the quantity of dissolved bone-black applied to A was not excessive, for while double the quantity, on plat H, gave 7 pounds less of ears it increased the yield of stover by 95 pounds. Mr. Yeomans's observation is noteworthy in this connection, that the ears on A were rather smaller, but more compact and sounder than on A, where a double quantity of dissolved bone-black was used, and many stalks had two ears, while on H there were no stalks with two ears.

If we call the average yield of the two plats which received no phosphate, C and F, 100 per cent, then the yields on the plats will compare as follows:

	Ears.	Stover.	Total. crop.
C and F, No phosphate.....	100	100	100
A, Dissolved bone-black	567	275	373
B, Grand Cayman's phosphate	312	160	211
D, Thomas-slag	211	136	161
E, South Carolina rock.....	191	136	155
G, Bolivian guano.....	194	155	168
H, Double quantity bone-black	550	387	442

Looking first at the yield of ears; where dissolved bone-black was used only a small portion of the ears were soft or immature, but everywhere else the proportion was large, and except on B, Grand Cayman's phosphate, much more than half. Dissolved bone-black produced nearly three times the weight of sound ears that the Grand Cayman's phosphate produced and about seven times as much as any other phosphate.

Of stover, dissolved bone-black yielded one and three-quarter times as much as Grand Cayman's phosphate or Bolivian guano and twice as much as Thomas-slag or ground South Carolina rock.

Results.—In general it may be fairly said that in this experiment, this year, dissolved bone-black yielded twice the return that an equal money value of any other phosphate yielded, that Grand Cayman's phosphate came next, though greatly inferior in effect, and that Bolivian guano, Thomas-slag, and ground South Carolina rock did not differ greatly in crop-producing power, and the plats which received them gave about one and a half times as much crop as those which received no phosphates.

The general results are thus summarized:

The experiment made by Mr. Bartholomew with corn in 1887, the repetition of that experiment in 1888, his experiment with potatoes in 1888, Mr. Yeomans's experiment with corn in 1888, and perhaps Mr. Platt's experiment, are the only ones which can fairly be regarded as contributions to the question of the relative practical value of the phosphates under experiment.

In Mr. Bartholomew's experiment of 1887 Grand Cayman's phosphate and Thomas-slag produced as large a crop of ears, more stover, and as large a total crop as the same money value of dissolved bone-black produced, while ground South Carolina rock produced less than half as much increase of crop over land which had no phosphates.

In 1888, with no further addition of phosphates, the plat which the season before had received Grand Cayman's phosphate gave three times as much increase of sound ears over the no-phosphate plots as the plat which had received dissolved bone-black, more than twice as much increase of stover, and more than three times as much increase of total crop. The plat which had received Thomas-slag gave still larger in-

crease of crop. The plat which had ground South Carolina rock the year before, produced in 1888 more than twice as much increase of ears and two and a half times as much increase of total crop as the dissolved bone-black.

These results are differently expressed in this statement of total yield of ears and total crop for the two years.

	Yield of ears.	Total crop.
A, Dissolved bone-black.....	1, 040	1, 946
B, Grand Cayman's phosphate.....	1, 100	2, 144
D, Thomas-slag.....	1, 079	2, 099
E, Ground South Carolina rock.....	1, 007½	1, 926
C and F, No phosphate (average).....	942	1, 713

There was profit in dollars and cents in the use of either dissolved bone-black or the raw phosphates, Grand Cayman's, and Thomas-slag; but *on this land, in these two years*, raw phosphates paid better than superphosphates.

There was no loss, perhaps, in the use of South Carolina rock. These conclusions are confirmed by the following statement of yield per acre for the two years:

	Total yield of ears for two years.	Bushels of shelled corn. *	Gain in bushels.	Cost of phosphate.
A, Dissolved bone-black.....	8, 320	104	10	\$3. 36
B, Grand Cayman's phosphate.....	8, 800	110	16	3. 36
D, Thomas-slag.....	8, 632	107	13	3. 36
E, South Carolina rock.....	8, 060	101	7	3. 36
No phosphate.....	7, 536	94	.....	.....

* Eighty pounds of ears to the bushel.

There now remains on the plats B, D, and E, not removed by the crops, the following quantities of phosphoric acid, which were applied two years ago:

	Pounds.
Plat B.....	86. 7
Plat D.....	59. 3
Plat E.....	97. 8

All of the phosphoric acid applied to plat A has been removed in the two crops, and more besides.

Next we may consider Mr. Bartholomew's potato experiment. First on the rye land. Here the yield of potatoes, both large and small, was about the same on the separate plats, which received equal money values of dissolved bone-black, Grand Cayman's phosphate, and Thomas-slag, though the last-named produced a larger proportion of small potatoes than the others. Each of these phosphates increased the yield about one-quarter over that of the no-phosphate plats. Bolivian guano increased the yield half as much, and South Carolina rock did not increase it at all. Each plat contained one-sixteenth of an acre. If we figure the crops of large potatoes to the acre and call 60 pounds of potatoes a bushel, the yields are as follows:

	Bushels per acre of large potatoes.	Gain in bushels.	Cash value of gain.*	Cost of phosphate.
No phosphate.....	127	.....	.....	.....
Dissolved bone-black.....	165	38	\$19. 00	\$4. 16
Grand Cayman's phosphate.....	164	37	18. 50	4. 16
Thomas-slag.....	156	29	14. 50	4. 16
South Carolina rock.....	123	.....	.....	4. 16
Bolivian guano.....	144	17	8. 50	4. 16

* Reckoning the potatoes at the low price of 50 cents a bushel.

The experiment on meadow land gave very different results. Here dissolved bone-black produced 25 per cent of increase in total crop, while neither of the other phosphates produced half as much, and the plat to which Bolivian guano was applied for some reason produced less than the no-phosphate plats. The yield in bushels per acre, the gains over the no-phosphate plats, and the cash values of the gains are as follows:

	Bushels per acre of large pota- toes.	Gain in bushels.	Cash value of gain.	Cost of phosphate.
No phosphate.....	139	.....	.....	.....
Dissolved bone-black	177	38	\$19.00	\$4.16
Grand Cayman's phosphate.....	148	9	4.50	4.16
Thomas-slag	149	10	5.00	4.16
South Carolina rock.....	152	13	6.50	4.16
Bolivian guano	131	.....	.....	4.16

It appears that there was three to four times as much profit from the use of dissolved bone-black as from the use of the raw phosphate in this first crop. It remains to see what the after effect of the different phosphates will be. At present we have no explanation to advance for the very different effects of the phosphates on two pieces of ground in the same field with the same exposure, the only difference between them being that one was inverted sod, while the other had been plowed a year and a half before and had grown rye.

We come now to consider Mr. Yeomans's experiment.

Mr. Yeomans's land, like Mr. Bartholomew's, is strikingly benefited by phosphates. Any phosphate, raw or dissolved, put on in moderate quantity will pay well. It is even more strikingly benefited than Mr. Bartholomew's land. The results are, however, very different from Mr. Bartholomew's. Dissolved bone-black yielded from nearly three to ten times as much sound ears as any other phosphate. Where no phosphate was used there was scarcely any sound corn. It yielded from one and three-quarters to twice as much stover also as any raw phosphate. It is fair to say that dissolved bone-black on this land, this year, yielded twice the money return of any other phosphate.

At present no explanation can be given of this difference in the comparative effects of the same phosphates on different land. It is hoped that further experiments by these gentlemen may make the matter clearer. We believe that the difference will be found to be partly if not largely due to difference in season. August and early September of 1887, when Mr. Bartholomew's first experiment was tried, were months particularly favorable for the growth of corn, and during those months the raw phosphate plats which earlier in the season were noticeably backward, advanced rapidly and overtook the dissolved bone-black plat which had been leading them in growth. On the other hand, August and September of 1888, when Mr. Yeomans's experiment was tried, were unfavorable to the growth of corn, being cold and wet, and the raw phosphates, which are presumably slower in affecting the crop, could not be so well utilized. A repetition of Mr. Yeomans's experiment, such as Mr. Bartholomew made in 1888 on the land used in 1887, is extremely desirable.

In Mr. Platt's experiment only the sound ears were weighed, but Thomas-slag, South Carolina rock, and Bolivian guano gave practically as large a crop as dissolved bone-black.

In general it has been shown that in some cases the raw phosphates may be more profitable to use than dissolved phosphate, that their effects are more lasting, and that the immediate effect in some cases may be as great as that of the same money value of dissolved phosphate. This is a matter of great importance to users of commercial fertilizers and will receive further study on the part of the Station.

To any in the State who may wish to test the effect of raw phosphates on their

land for themselves and will engage to follow the Station's directions for making the test and will report the results to the Station for general use, the Station will supply these phosphates so far as it is possible.

It is worth noting that the largest yield of sound ears per acre in the single experiments has run from 2,980 pounds to 5,860 pounds, or, allowing 80 pounds of ears to the bushel, from 37 to 73 bushels per acre.

In conclusion, it is a pleasure to acknowledge the readiness with which all those engaged in carrying out the experiments here described have accepted the plan suggested by the Station, and the care and accuracy with which the experiments have been conducted. In every case where there has been partial or complete failure this has been due to circumstances of weather or to peculiarities of soil which could not be foreseen, not to any neglect on the part of the experimenter. Of the twelve experiments, four have value in connection with the special point which was studied, viz: the relative practical value of the different phosphates, while eight experiments have little or no value of this kind. Some of them, however, show incidentally what fertilizing elements have special value for the soil under experiment. This general result is about what was anticipated and is not discouraging.

The question, which pays best, plain superphosphate or an equal money value of raw phosphate, is an important one to the farmers of this State, who are spending yearly more than \$200,000 for phosphoric acid.

If this question can be settled at all it will be by such experiments as we have described, carried out in all parts of the State by farmers with the co-operation of the stations. Even if this question shall not be answered in a perfectly satisfactory way its study will nevertheless diffuse information and may in other ways richly repay for the labor and expense.

FEEDING STUFFS (pp. 141-154).—About two hundred samples of feeding stuffs have been analyzed, including a number obtained from field experiments conducted under direction of the Station.

An attempt has been made by the Station to find out and analyze all the mill products now in the Connecticut market, whose average composition is not already known, and also to offer some method of comparison or "valuation" for them.

The method here to be described is not a new one. It has been used abroad, where feeds as well as fertilizers are sold under guarantee as to composition, and the seller is obliged to make good any deficiency. The method is perfectly logical only when the price of each feeding stuff is governed strictly by its composition. In England and Germany this appears to be much more nearly the case than in this country, where prices at present are regulated scarcely at all by the chemical composition of the feeds. Notwithstanding this the valuations obtained by the method as below described have in general agreed well with the market prices of the standard mill-feeds.

An outline of the method is as follows:

The average market prices of the feeds which form the basis of calculation can be obtained from the market reports, just as the market prices of nitrogen, phosphoric acid, and potash are obtained from the weekly quotations of fertilizer chemicals. The chemical composition of the feeds can be determined by analysis, as the composition of fertilizer chemicals is determined.

The next step is to calculate from the chemical composition of all the feeds and their retail prices the most probable or average retail price of a pound of albuminoids or fat or carbohydrates (fiber and nitrogen-free extract together). This problem is by no means so simple as that of determining the cost of nitrogen, phosphoric acid, or potash. Each of the last named can be bought by itself; potash, for instance, in muriate of potash or nitrogen in dried blood, and from the price of the muriate or the blood the cost per pound of potash or nitrogen can be directly deduced. But there are no feeds which contain only one or even only two food ingredients. All of them contain at least three. Under these circumstances to calculate the cost of each food ingredient can only be done algebraically by an application of the "method of

least squares," so called. The tedious details of the calculation would be out of place here. The data used for solving this problem are as follows :

By correspondence with dealers throughout the State, as well as with purchasers, the average retail prices of fine feed (as distinguished from coarse feed, hay, stalks, straw etc.), have been obtained as accurately as possible. The average composition of these feeds is known from the tables of analyses which are annually revised and published by this Station. A considerable number of analyses have also been made within the last two months of feeds new to our market, so that we have a tolerably complete statement of their composition.

The feeds used in calculating the average cost of albuminoids, fat, and carbohydrates are those in the subjoined list.

The selling prices per ton are believed to represent the average for December, 1888.

Fine feeds, cost, and valuation.

Feeds.	Selling price per ton.	Valuation.
Cotton-seed meal.....	\$27.75	\$30.37
Linseed meal, old process.....	32.25	25.92
Wheat bran.....	20.50	20.22
Wheat middlings.....	22.00	21.20
Rye bran.....	21.00	19.89
Corn meal.....	21.50	19.59
Gluten meal.....	23.00	25.38
Hominy chops.....	21.00	23.31
Malt sprouts.....	17.00	20.27
Oat middlings.....	25.00	24.31
Rye feed.....	20.00	19.62
Total.....	251.00	250.08

The calculation based on these foods and their average composition and prices at the date named shows that the average retail cost of a pound each of albuminoids, fat, and carbohydrates is as follows :

Cost of food ingredients.

	Cents.
Albuminoids (N. $\times$ 6.25)	1.6
Fat	4.2
Carbohydrates	.96

To test the accuracy of these figures they have been applied to the feeds from which they were derived and the results are given above in the column headed "Valuation." It appears that the total calculated cost and the total actual cost agree within \$1. It may be noted in passing that these figures differ radically from those used in Germany, which were derived in a similar way from German market quotations, and which, in absence of any other data, have been previously applied to American feeding stuffs.

To explain their use they are here applied to a sample of malt sprouts, the analysis of which is given on page 152 of the report.

	The sample contains in 100 pounds—	The sample contains per ton—	Cost per pound.	Ton value.
			<i>Cents.</i>	
Albuminoids	23.87	477.4	1.6	\$7.64
Fat.....	1.38	27.6	4.2	1.16
Carbohydrates*.....	58.81	1176.2	.96	11.29
Total.....				20.09

* The sum of nitrogen-free extract and fiber.

Cost	\$15.00
Valuation.....	20.09

The meaning of this statement must be clearly borne in mind. It does *not* mean that this feed is certainly worth for feeding purposes \$5.09 more per ton than it costs. It does *not* mean that malt sprouts are certainly worth more than another feed which has a lower valuation. It does *not* mean that it is a palatable and easily digestible food. What this numerical statement does mean is this: that in malt sprouts of this quality and price the purchaser gets the food ingredients named for less than their average market price by \$5.09. This leaves a great deal to be known about the feed, to be sure, but it nevertheless is a very useful piece of information. To illustrate: To know that potash in muriate costs $4\frac{1}{2}$ cents a pound, while in sulphate it costs $5\frac{1}{2}$ cents, leaves much still to be known about the agricultural uses of these two salts, and spite of the difference in cost there will be much use wisely made of the more costly one; but a knowledge of this difference is of great value to purchasers of potash salts. Just so to know that albuminoids, fat, and carbohydrates cost very much less in malt sprouts or cotton-seed meal than in wheat bran will not induce an intelligent dairyman to give up bran and feed malt sprouts or cotton-seed meal wholly in its place, but it may induce him to try substituting one of these for a part of the bran or other feed which he uses, and when he finds a new feed offered he will be disposed to look not only on its gross cost but on the cost of the food ingredients in it as compared with the usual market rates. These figures are provisional and will change somewhat with the state of the market. They apply only to one class of feeds, namely, dry fine mill-products or brewery refuse like malt sprouts and dried brewers' grains.

FURTHER OBSERVATIONS ON THE MECHANICAL ANALYSIS OF SOILS,
THOMAS B. OSBORNE, Ph. D. (pp. 154-157).—An account of experiments made on boiling clayey soils with water.

Storrs School Agricultural Experiment Station.

Connected with Storrs Agricultural School.

Location, Mansfield (Storrs P. O.). Director, W. O. Atwater, Ph. D.

FIRST ANNUAL REPORT, 1888.

REPORT OF EXECUTIVE COMMITTEE (pp. 7-11).—The report contains the resolution of the legislature (approved May 18, 1887) establishing the Station, under the act of Congress of March 2, 1887, the act relating to the publications of the Station, and the plan under which the Station was organized.

ORGANIZATION AND OPERATIONS OF THE STATION (pp. 11-13).—The farm and farm appliances, and the labor of the students of the Storrs School, are utilized by the Station. A building has been erected for the office of the Station on the grounds of the school. The work at Mansfield, the grass and forage garden there, and the field experiments throughout the State are under the immediate charge of the vice director. The more purely scientific investigations are carried out at Middletown, in the chemical laboratory of Wesleyan University.

The work actually undertaken up to June 30, 1888, included—

(1) Co-operative field experiments on the effects of fertilizers and the production of crops. These have been performed by the Station in Mansfield, and by a considerable number of farmers under the direction of the Station, in all of the counties of the State.

(2) Vegetation experiments in pots and boxes for studying the sources of nitrogen of plants.

(3) The establishment of a grass and forage garden to test the adaptability of grasses and other plants for culture in Connecticut.

Plans were made for experiments upon the effects of surface tillage upon soil moist-

ure, for the study of the root development of plants, and of the values of foods and feeding stuffs, by chemical analysis, and experiments with the calorimeter.

From June 30 to December 31, 1888, the force of the Station has been chiefly engaged in carrying out the lines of experimenting indicated above.

The work in the chemical laboratory has included analysis of the plants and soils from the pot experiments, of the roots mentioned above, and of thirty-six specimens of food and fodder materials, studies of some methods of analysis, and the beginning of a series of analyses of samples of corn and stover from certain of the field experiments.

An investigation of the micro-organisms that have to do with fermentation and other changes that take place in milk and during the ripening of cream has been undertaken.

The organization and first work of the Station, including field experiments, were described in Bulletin No. 1. The work of the vice director and his assistant in the grass and forage garden, and their experiments on the effects of surface tillage, were described in the Bulletin No. 2. Their observations on the roots of plants and the results of analyses of roots by the chemist were given in Bulletin No. 3.

REPORT OF DIRECTOR (p. 21).

EXPERIMENTS ON THE EFFECTS OF TILLAGE ON SOIL MOISTURE (pp. 22-27).—These experiments are part of a series undertaken on the school farm by C. S. Phelps, B. Sc., vice director. They were naturally tentative, and, in the judgment of the experimenters, crude, but confirm the results of other experimental inquiry.

Description of the experiments.—Eight cans made of galvanized iron, each 30 inches deep and 10 inches in diameter, were used for holding the soil. A half-inch pipe connecting with the interior was soldered on the outside of the can 2 inches above the bottom. By means of a rubber tube extending from the pipe to the top of the can weighed quantities of water were added when desired. Boxes of 1½-inch chestnut plank, without bottoms, of the same height as the cans and large enough to hold them, were sunk into the earth in the forage garden, so that the tops were even with the surface of the ground. The cans of soil were kept in these boxes and removed only for weighing. The surface of the soil within the cans was at the same level as that of the ground outside. On the top of each can a thin cylinder of galvanized iron 2 inches high and 10 inches in diameter was accurately fitted. These cylinders served as rain-gauges, conducting the same amount of rain-fall into each can. The rain-fall for August being above the average, water was added artificially but twice, all the cans receiving the same amounts.

Two kinds of soil were used for the experiments; one was from rather low land, that of the grass and forage garden, and the other from grass-land on the top of the hill near the laboratory of the school. The cans were filled so that the soil stood, as nearly as possible, at the same depth in the cans as it previously did in the fields from which it is taken. That is, soil from a depth of 20 to 30 inches was placed in the bottom 10 inches of the can; soil from a depth of 10 to 20 inches in the middle 10 inches; and the upper part of the can was filled with the surface soil. The earth was put into the cans in successive layers of about 1 inch in depth, and each layer gently tamped in order to make the soil in the cans as uniform in compactness as possible.

The eight cans were divided into lots of four each. The soil in one lot was heavy loam with clayey subsoil; that in the other, light loam with sandy subsoil. The surface of the soil in two cans of each lot was stirred frequently—numbers 4 and 5 to a depth of two and numbers 3 and 6 four inches, while the other cans were not disturbed.

Lot I (Nos. 1, 2, 3, and 4).—Soil from forage garden. Subsoil, lower 20 inches, a yellow clay loam of nearly uniform texture. Surface soil, top of can, a rich, heavy loam.

Lot II (Nos. 5, 6, 7, and 8).—Upland soil. Ten inches at the bottom of can nearly pure sand. Middle 10 inches porous, light loam. Remainder, top of can, from first 5 inches below the sod, a light loam, apparently containing small percentage of organic matter.

The experiment was commenced July 31, but heavy rains interfered at times. The period between August 15 and August 31, however, was for the most part dry and warm enough to show clearly the effects of evaporation, though it was by no means a time of drought.

The report contains tables giving the detailed results. The following is a summary of these tables:

Loss by evaporation from August 15 to August 31.

Condition of surface.	Lot I. Heavy soil.		Lot II. Light soil.		Lot I. Heavy soil.	Lot II. Light soil.
	<i>Lbs.</i>	<i>oz.</i>	<i>Lbs.</i>	<i>oz.</i>	<i>Inches.</i>	<i>Inches.</i>
Not stirred	4	13.0	3	5.0	1.69	1.16
Not stirred	4	9.0	4	2.5	1.62	1.46
Stirred 2 inches*	3	10.5	1	12.5	1.29	.62
Stirred 4 inches*	3	8.0	2	3.0	1.23	.77

* Stirred every alternate day, unless prevented by rain.

The meaning of the experiment.—In the October bulletin of the Station the results of the experiment and their bearing upon tillage were discussed at considerable length.

In dry weather water escapes from the upper layers of the soil in two ways. It is taken up by the roots of plants and exhaled through the leaves, and it evaporates from the surface by the action of sun and wind. The water which passes through the plant brings it sustenance, and is on this account most useful to the farmer. That which evaporates from the soil is so much lost to him.

In these experiments during the last half of August, although the weather was neither particularly warm nor dry, the heavy soil lost four-tenths of an inch less water, and the light soil six-tenths less by evaporation when stirred at the surface than when not stirred.

Hoeing and cultivating the land on which crops are growing permits nature to bring the stores of water to the roots of the plants, so that they may live and thrive upon it and the plant food it brings, but tends to prevent its passing into the air and thus being lost.

The substance of the lesson taught by these experiments may be summed up in a few words.

It is not simply for the sake of killing weeds that the farmer hoes his corn. Weeds are his enemies, but drought is worse; and the moisture is often insufficient for full yield even when no drought is apparent. The soil has reserve stores of water for his crops, but in summer the supply gets low, and the same force of capillarity which brings it up to where the roots of his plants can get it carries it past them to the surface, where the sun's heat changes it to vapor and winds bear it away. Hoeing and cultivating loosen the upper layer of the soil. The pores through which the water is drawn up are thus enlarged and the connection between them is broken; capillary action is consequently hindered and less water passes through. At the same time more air enters, and the loosened layer conducts less heat to the soil beneath. The loosened layer acts as a mulch, and tends to keep the soil below cooler while it prevents the water from reaching the surface, and thus in a twofold manner protects the rising moisture from evaporation. In this way the wise cultivator uses the forces of nature to bring water to the roots of his plants and at the same time to prevent its passing by them and escaping into the air. The water is freighted with

plant food—part of it brought from below, part of it dissolved from the soil about the roots and part derived from the air above. So the crops are nourished and the yield of the land increased.

ROOTS OF PLANTS AS MANURE, C. D. WOODS, B. SC. (pp. 28–43).—In this article are published the results of analyses of the roots of wheat, timothy, and clover, made by Professor Atwater and assistants in 1878 (see Report of the Connecticut Board of Agriculture for 1878), combined with those of similar analyses made in 1888.

Methods of obtaining specimens.—The specimens of roots and stubble for analysis were obtained from portions of the field representing, as nearly as could be determined, an average condition of the crop grown. After removing weeds and other foreign matter, a trench about 2 feet deep and large enough for convenience in working was dug on all sides of a small section of earth, leaving a square block in the center a little more than 2 feet on a side.

The sides of this earth block were carefully trimmed until it was exactly 2 feet square, thus making an area of 4 square feet, or $\frac{1}{10890}$ of an acre. By means of a cord drawn tightly around the block, sections 6 inches in depth were marked off and the earth from each layer removed into separate boxes. The trench was deepened as required for convenience in working as layers were removed.

Each section of the earth was worked over separately by hand labor, the roots, stubble (and in the case of the grass, the new growth), being separated from the soil and from the roots of weeds as far as possible. The fine, hair-like roots could not all be secured, but these represent so small a portion of the whole that the results could not have been materially affected.

The article contains a description of the specimens used in the experiments, the methods of analyses, and tables giving the details of the results of the analyses. The following table gives the weight of roots (or roots and stubble), and of the ingredients per acre in the experiments named, and with them corresponding results of observations made by Dr. Voelcker in England, and Dr. Weiske in Germany.

Amount of roots and stubble and valuable ingredients left in one acre, with valuable ingredients in manures.

Kind of plant and portion analyzed.	Roots and stubble.	Nitrogen.	Phosphoric acid.	Potash.
<i>Reported herewith.</i>				
	Water free.*			
	Pounds.	Pounds.	Pounds.	Pounds.
Cow-peas; stubble and roots to depth of 6 inches.....	711	10.0	2.7	5.3
Cow-peas; stubble and roots to depth of 3½ feet	1,095	14.5	2.8	6.4
Timothy and redtop; stubble and roots to depth of 6 inches..	7,606	83.7	23.8	53.5
Timothy and redtop; roots below 6 inches to depth of 3 feet..	617	6.4	1.4	2.3
Timothy and redtop; stubble and total roots to depth of 3 feet.	8,223	90.1	25.2	55.8
Buckwheat; stubble and roots to depth of 1 foot	483	4.4	1.3	3.8
<i>Middletown Station, W. O. Atwater.</i>				
Timothy; roots.....	2,240	31.1	7.0	8.4
Wheat; roots.....	658	6.4	1.5	2.6
Clover; roots.....	1,335	35.5	10.0	15.0
<i>Dr. Voelcker, England.</i>				
"Good clover;" first year; roots.....	4,155	100.0	.....	.....
"Bad clover;" first year; roots	1,550	31.0	.....	.....
"Thin clover;" second year; roots.....	7,026	66.0	29.5	.....
"Good clover;" second year; roots.....	6,503	65.0	27.0	.....
Clover; first year; mown twice; roots.....	1,493	24.5	.....	.....
Clover; first year; mown once; roots	3,622	51.5	.....	.....

Amount of roots and stubble and valuable ingredients left in one acre, etc.—Continued.

Kind of plant and portion analyzed.	Roots and stubble.	Nitrogen.	Phospho- ric acid.	Potash.
<i>Dr. Wieske, Germany</i>				
	Air dry.			
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Rye; roots and stubble	3,400	62.0	24.0	30.0
Barley; roots and stubble	1,515	22.0	11.0	9.0
Oats; roots and stubble	2,200	25.0	28.0	24.0
Wheat; roots and stubble	2,240	22.0	11.0	17.0
Red clover; roots and stubble	6,580	180.0	71.0	77.0
Buckwheat; roots and stubble	1,630	45.0	10.0	9.0
Peas; roots and stubble	2,400	53.0	14.0	11.0
Lupine; roots and stubble	2,800	58.0	13.0	16.0
<i>Fertilizers.</i>				
Rich stable manure*	2,000	10.0	10.0	8.0
Nitrate of soda	100	16.0	.....	.....
Dissolved bone-black	100	.....	16.0	.....
Ground bone*	100	3.0	22.0	.....
Muriate of potash	100	.....	.....	50.0

*Analyses taken from Farmers' Annual, 1882, Jenkins and Armsby.

Among the practical conclusions drawn from these experiments are the following:

So far as it is safe to judge from the figures contained in the table, wheat, oats, and buckwheat leave much less plant-food in the soil than the other crops. Probably the grain crops as a class are of comparatively little value in enriching the soil for following crops.

Clover, cow-peas, and other legumes have a peculiar power of gathering plant-food, and especially nitrogen, from natural sources. Although they contain much more nitrogen than wheat, oats, and similar grains, they thrive and bring large yields where wheat will not. While their especial faculty for gathering nitrogen from the stores in the soil and probably from the air is not yet explained, the important fact here is that they do gather it and leave a great deal of it in the roots and stubble. Nitrogen is the costliest ingredient of fertilizers. These facts help to explain the economy of clover for manure, and why clover is so valuable as a preparatory crop for wheat and other grains.

The above-cited facts would seem to imply that the legumes, such as clover, are especially valuable for this kind of manuring; that timothy and other grasses stand next; and that the grain crops leave the least amounts of plant-food in roots and stubble.

METEOROLOGICAL OBSERVATIONS, C. S. PHELPS, B. SC. (pp. 43–46).

CO-OPERATIVE FIELD EXPERIMENTS WITH FERTILIZERS, C. S. PHELPS, B. SC. (pp. 47–94).

During the past season the Station instituted, in different parts of the State, a series of experiments with fertilizers. These have been conducted upon a variety of soils and in various localities, the aim being to have at least one experiment in each county. The object of these experiments is threefold.

(1) To work directly upon farm lands in different parts of the State and aid the owners in determining the deficiencies of their soils and the requirements of their crops.

(2) To help practical farmers to become familiar with the more important fertilizing materials containing nitrogen, phosphoric acid, and potash, their action upon

different soils and crops, and to encourage them to investigate for themselves the complicated questions involved in a rational and profitable use of fertilizers.

(3) Thus to gradually develop a number of trained farm-experimenters, whose work will be useful not only to themselves, but in larger degree to their communities and to the agriculture of the State.

The article contains detailed directions for the conduct of these experiments, and the details of each experiment performed, including a tabular statement of results.

The experiments conducted during the season of 1888 may be divided into three classes :

I. Experiments for soil tests.

II. Experiments for testing the effects of different quantities of the same fertilizers.

III. Experiments for studying the effects of different quantities of nitrogen upon the corn crop.

The plans for the experiments of Class I were essentially the same as were adopted at the conference of representatives of Experiment Stations at the Department of Agriculture in March, 1889, and described in Circular No. 7 of the Office of Experiment Stations. Those of Class III were described in the same circular.

The following are some of the practical deductions drawn from these experiments :

In these experiments the largest yields, in most cases, were from the complete fertilizers. In many cases, however, one or two ingredients that seemed to meet the special requirements of that particular soil, gave much larger profits; for example, potash in the case of Mr. Deane of Falls Village; phosphoric acid and potash (mixed minerals) with Mr. Bartholomew, of Putnam; and nitrate of soda (nitrogen) with Mr. Williams, of Brooklyn.

The following tabulation, prepared from the results of eighty different experiments, conducted under the direction of Professor Atwater during the years 1878-81, will be of value in this connection. The phosphoric acid (superphosphate) was called the regulating ingredient when the crop was largely benefited by it in every plat to which it was applied, and gave little or no response to the other materials. Where the crop paid less exclusive heed to the phosphoric acid, but was yet clearly benefited by it, it was called more or less efficient. Where the increase with phosphoric acid was less than four bushels per acre, it was counted as insufficient. The same rule was applied to the other materials.

Effect of fertilizing materials on corn—eighty experiments.

	Regulating ingredient.	More or less efficient.	Inefficient.
Superphosphate (phosphoric acid)	29	34	17
Muriate of potash (potash)	12	24	44
Nitrate of soda (nitrogen)	4	30	46

The results of these and other experiments indicate that phosphoric acid commonly, potash often, and nitrogen occasionally, are decidedly important ingredients of fertilizers for corn.

In the special nitrogen experiments the inefficiency, especially from a pecuniary point of view, of large quantities of nitrogen, is clearly shown. As soon as the "one-third nitrogen ration" (24 pounds per acre) was exceeded, the profits became less, and the full rations were invariably used at a considerable loss.

The fact brought out by these experiments, and similar ones conducted in past years, is that corn can be grown with greater profit on mineral fertilizers alone, or with the addition of small quantities of nitrogen, than by the use of large amounts of this costly ingredient. The quantity of nitrogen it is advisable to use varies with different soils. Corn grown on soils that are naturally deficient in vegetable matter or humus is generally benefited by nitrogenous fertilizers to a greater degree than where the soils contain abundance of this substance.

In the following table are given the results from the use of mixed minerals, and small and large quantities of nitrogen, in a large number of experiments conducted during a period of years from 1878 to 1881, and the average of those conducted by the Station during 1888. In preparing this table the results from a large number of plats to which phosphoric acid and potash (mixed minerals) alone had been applied were averaged, for comparison with those furnished with the same mineral fertilizers but having in addition nitrogen equaling, approximately, one-third, two-thirds, and the full amounts contained in an acre of corn and stover yielding 50 to 60 bushels of shelled corn:

Yields per acre.

	Eighteen experiments, 1878-'81.	Four experiments, 1888.
<i>Special nitrogen experiments.</i>		
	<i>Bushels.</i>	<i>Bushels.</i>
Mixed minerals alone.....	43.0	33.4
Same + 24 pounds nitrogen.....	48.4	38.2
Same + 48 pounds nitrogen.....	48.8	40.2
Same + 72 pounds nitrogen.....	49.6	39.2
<i>Seventy-five general experiments.</i>		
Mixed minerals alone.....	43.4	.....
Same + 24 pounds nitrogen.....	47.8	.....

It is assumed that a crop of corn of 50 to 60 bushels, with the stalks, removes from the soil in the neighborhood of 70 to 75 pounds of nitrogen. Thus it will be seen that where there is an amount of nitrogen equal to one-third or even less of the total quantity represented in the crop, the corn is generally able to obtain from some source or other the remaining 48 or more pounds, and give about as good a crop as where the full amount of nitrogen represented in the crop is applied.

The important facts to be learned from all of these experiments are, that the corn plant has been able to develop and produce fair crops where mineral fertilizers alone were employed, even on our worn-out New England soils; that in some way corn does obtain large quantities of nitrogen from natural sources, either from soil, or air, or both, and that corn is unlike other cereals, as wheat and oats, and can not be fertilized in the same way with profit.

Conclusions.—Taking into consideration these and similar experiments conducted in former years, the results show more clearly than ever that—

(1) Soils vary widely in their natural stores of fertility, and hence in their capacities for supplying crops with food, and in their demands for fertilizers.

(2) Farmers can not afford to use commercial fertilizers indiscriminately, but when properly used they are not only a valuable auxiliary to farm manures, but frequently produce better and larger crops when used exclusively than where yard-manures are used alone.

(3) The most convenient way to determine the requirements of a soil for the production of any particular crop is to put the question to the soil itself with different kinds and combinations of plant-food.

(4) Field experimenting must be considered an important branch of the work of Experiment Stations. If these experiments are carefully planned, faithfully carried

out, and the results interpreted by the aid of the most advanced science, they will bring us nearer the solution of many important problems—problems, too, such as the Eastern farmer has to contend with in the daily operations of the farm.

GRASSES AND FORAGE PLANTS GROWN DURING 1888 (pp. 94–96).—The article contains a list of the plants under cultivation in the grass and forage garden.

EXPERIMENTS ON THE COW-PEA (pp. 96–98).—The article contains a brief account of the preliminary experiments to determine the adaptability of the cow-pea to the climate of Connecticut, and to study its value as a forage and ensilage crop.

ORIGIN AND BOTANICAL AFFINITIES OF THE COW-PEA, PROF. W. H. BREWER (pp. 99–101).

It is probable that most of our varieties belong to the species known to modern botanists as *Vigna Catiang*, Endl., a native of northeastern Asia. The more important botanical synonyms are *V. Sinensis*, *Dolichos Catiang*, L., *D. Sinensis* L., and *D. melanophthalmus*, D. C.

The genera *Dolichos* and *Vigna* both belong to the section of the Leguminosæ to which the true beans belong. These genera have many species, natives of warm climates all around the world. Several species are cultivated, belonging to both genera, and the cultivated kinds have been carried to nearly all hot countries. As a consequence of this wide dispersion, it is now impossible to assign satisfactory limits to the species, and emphatically so of the cultivated ones, so whether all the varieties of “cow-pea” are derived from only one original wild species or not, must remain a matter of opinion rather than demonstration among botanists, for the varieties have been cultivated so long that it can not now be proved conclusively what the wild progenitor was. I strongly suspect that some few forms in the United States, known locally as “cow-pea,” belong to the species *Dolichos Lablab*, L. This species, also a native of India, and cultivated in various varieties, has been carried under various names to almost all hot countries, in some of which it has become naturalized and spread as a weed.

From what data he can gather, supplemented by his own, Professor Brewer concludes that—

At best only a few of the many varieties can profitably be cultivated in New England; but it is also evident that many kinds must be tried, and for a series of years, before condemning the plant as unprofitable. I believe that varieties may be found that can be profitably grown, especially for milch cows. But the seed must come each year from some southern locality. It has heretofore not been considered a profitable forage crop north of Delaware except under very exceptional circumstances. But, by modern methods, we may and perhaps will make it pay for certain purposes in Connecticut. It flourishes well in sandy soils, and should have a new and fair trial.

DAKOTA.

Dakota Agricultural Experiment Station.

Department of Dakota Agricultural College.

Location, Brookings.

Director, Lewis McLouth, Ph. D.

FIRST ANNUAL REPORT FOR YEAR ENDING JUNE 30, 1888.

REPORT OF DIRECTOR (pp. 5-13).—The Station was organized in accordance with an act of the legislature of the Territory, approved March 13, 1887.

During the summer and fall of 1887, 320 acres of land adjoining the original college plat of 80 acres were purchased for an experiment farm, a few fine specimens of a considerable number of breeds of registered domestic animals were bought, a large stock barn and other buildings were erected, teams and farm tools and machinery secured—all by means of funds granted by the legislature of the Territory.

The director was chosen November 17, 1887.

The scheme of organization adopted by the board of regents of the college March 13, 1888, in which the duties of officers of the Station are defined, is given on pages 6-8.

General plans of the work of the Station (pp. 10, 11).—The Station will undertake first only those practical problems in agriculture which most closely affect the interests of Dakota. The investigations of the Station for the present will deal very largely with matters relating to the climate.

The Station has started out to determine the length of the corn season, to find what grasses can be cultivated to take the place of the prairie pastures, to learn the profitableness of various root crops, to ascertain what forest and what fruit trees will grow best, and what kinds of garden vegetables can be easily cultivated to add variety to the farmer's bill of fare and to increase his profits. The entomologist is trying to find out the most successful manner of making war upon the insects that prey upon the growing crops from seed time to harvest. The chemist will make extended examination of the purity and healthfulness of the well waters of the Territory. Many, especially of the artesian waters, are said to have large amounts of mineral ingredients; these will be determined and pronounced upon. He will also make numerous soil analyses, especially of the so-called alkali soils.

Quite full sets of meteorological instruments have been procured, in part by purchase and in part by the courtesy of the U. S. Signal Service, and weather observations are being carefully made and records preserved. Every effort is being put forth to study the climatic conditions and to procure the enlargement and efficiency of the weather service of the Territory. As an illustration of the possible value of this service it may be stated that on the 12th of last January full telegraphic signals sent in advance of the not rapidly advancing storm would have saved many lives and much suffering.

Owing to the lack of proper equipment little work was done before the opening of the season of 1888.

REPORT OF DEPARTMENT OF FORESTRY AND HORTICULTURE, C. A. KEFFER (pp. 15-31).

A building has been erected for the use of the department of forestry, horticulture, and botany at a cost of \$3,000, this amount including the purchase of a Spence hot-water heating apparatus for the propagating room.

The building is a one-story structure, brick veneered to the tops of the windows, with a shingle course from the window-caps to the eaves. It is 28 by 46 feet in size, with a propagating room along the south side 18 by 46 feet, the roof and sides of which are of double strength glass. The main floor is divided into the following rooms: An office, microscopic laboratory, herbarium, grafting room, and tool room.

The cellar is 28 by 46 feet, 8 feet in the clear; it contains a commodious graft-storage room, besides fuel, boiler, and packing rooms. The attic is large, well lighted, and airy, and will be used for storing seeds. The floors of the main story are of hard pine, the wood-work of white pine, finished in oil.

The report contains a list of fruit trees and small fruits planted on the station grounds. In the garden especial attention is being given to the tomato and celery, vegetables not commonly grown in Dakota.

Forestry.—Last October a plat of between 2 and 3 acres was planted to forest-tree seeds. The different kinds were planted in irregular groups, in hills 4 feet apart, the intention being to have the trees stand permanently where the seed was sown, and it was thought by grouping the different varieties a mixed grove might ultimately be obtained, which would be similar to the natural woodlands of the East. All of the varieties planted save hickory, bass-wood, and black locust germinated this spring, but many of the seedlings were killed by cut-worms while very young. It is thought, however, enough remain to insure the success of the experiment. The vacant spaces may be replanted this fall. Varieties used: Box-elder, white ash, black wild cherry, honey-locust, white oak, burr oak, red oak, black walnut, white walnut or butternut, chestnut, hard maple, shell-bark hickory, and black locust.

The following varieties of seedling trees, in quantities from 200 to 2,000, were secured in the spring, and are growing in nursery rows this season. The evergreens were heavily mulched with straw, and have been very successful thus far. They were mostly from 4 to 10 inches high when planted, and have made a growth of from 1 to 3 inches. Next spring a forest plantation of 5 acres will be planted, using the trees which have been grown this season in the nursery.

Varieties.—European larch, yellow birch, black wild cherry, European white birch, box-elder, white ash, white elm, cottonwood, soft maple, white walnut, white oak, bass-wood, Scotch pine, white spruce, Norway spruce, balsam fir, Colorado blue spruce, Douglas spruce, arbor vitæ, white pine, red cedar, Black Hills native spruce, Black Hills native pine, hemlock, red pine, gray pine.

Experiments in the germination of forest-tree seeds.—At the time of planting the forest-tree seeds last October a quantity of seeds of several of the varieties used—principally box-elder and native white ash—were mixed with sand, boxed, and exposed on the north side of the main college building until the spring was well advanced, when they were planted in nursery rows. The box-elder and ash germinated, and I judge all grew. The oaks, walnuts, and hickories failed to germinate. I think probably they would have grown had they been planted earlier in the spring.

This spring a number of varieties of seeds, named below, were purchased, but were not delivered until late in April. They were soaked in cold water twenty-four hours, except the locust, on which boiling water was poured. They were then planted by the side of the seeds which were kept in sand over winter. Very few of the soaked seeds germinated, and with the exception of the honey-locust, all are now dead. The varieties used were white ash, box-elder, sugar-maple, blue ash, European ash, black ash, European bass-wood, American mountain ash, bass-wood, honey-locust, mountain maple, white thorn, choke-cherry, black wild cherry.

Notes on the trees growing in the college grounds (pp. 20–26).

Practical directions as to what trees to plant in Dakota and how to plant them (pp. 26–31).

REPORT OF AGRICULTURAL DEPARTMENT, LUTHER FOSTER, M. Sc. (pp. 32-43).—The report contains a list of the varieties of corn, grasses, clovers, forage plants, roots, and potatoes under experiment. The results obtained from the wheat, oats, and barley planted in 1887 are tabulated.

DELAWARE.

The Delaware College Agricultural Experiment Station.

Department of Delaware College.

Location, Newark.

Director, Arthur T. Neale, Ph. D.

FIRST ANNUAL REPORT, 1888.

REPORT OF PRESIDENT OF COLLEGE AND PRESIDENT OF BOARD OF TRUSTEES (p. 5-16).—The report contains a description of the new Station laboratory (page 6), with a picture of the exterior of the building, and two plans of the interior. It also includes an account of the appliances and apparatus provided for the work of the different departments. The present director entered upon his duties January 1, 1889.

FLORIDA.

Agricultural Experiment Station of Florida.

Department of Florida State Agricultural and Mechanical College.

Location, Lake City.

Director, Rev. J. P. De Pass.

ANNUAL REPORT FOR 1888.

REPORT OF DIRECTOR (pp. 2-5).—This Station has undertaken experiments with a considerable variety of fruits and forage plants, field experiments with fertilizers, and feeding experiments with Jersey cows.

In entomology, a collection of Florida insects has been begun, and the study of a life-history of insects injurious to the tobacco plant is now in progress.

In botany, the study of the character of common weeds of Florida, with reference to their value for forage, restoration of the fertility of the soil, and medicinal uses, together with studies in cross-fertilization, are contemplated.

In chemistry, analyses of the soils of the Station farm, and waters from Lake City and Jacksonville are reported in Bulletin No. 3. Other work of a similar character already accomplished will be reported in future bulletins.

A Station laboratory, which will cost about \$5,000, is nearly completed.

GEORGIA.

Georgia Agricultural Experiment Station.

Department of State College of Agriculture and Mechanic Arts, University of Georgia.

Location, Athens.

Director, W. L. Jones, M. D.

FIRST ANNUAL REPORT, 1888.

REPORT OF THE BOARD OF CONTROL (pp. 2, 3).

The legislature of Georgia, which met in July, 1887, having failed to take action regarding the act of Congress of March 2, 1887, a supplementary act was passed by Congress in June, 1888, authorizing the governor to give the necessary assent of the State. This was done by executive order on the 14th of June, 1888.

The property appropriated to the Station by the trustees of the university comprises the place known as the Rock College, a tract of 60 acres of farming land, a large three-storied building, affording ample room for every purpose, with outbuildings and stables, and, in addition to this, laboratories and offices on the campus, in which certain scientific work of the Station could be conducted.

REPORT OF DIRECTOR (pp. 4-11).—The report consists for the most part of an account of the equipment of the Station. The Station has records of meteorological observations made at Athens, Ga., for a number of years. The results of these observations were published in Bulletin No. 2, January, 1889, of the Station.

The chemist has begun investigations of the fuel values and ash content of the common woods in the neighborhood of the Station. The results thus far obtained are published in Bulletin No. 2, January, 1889.

ILLINOIS.

Agricultural Experiment Station of the University of Illinois.

Department of the University of Illinois.

Location, Champaign.

Director, Selim H. Peabody, Ph. D., LL. D.

FIRST ANNUAL REPORT FOR THE YEAR ENDING JUNE 30, 1888.

REPORT OF THE TRUSTEES OF THE UNIVERSITY (pp. 1-15).—The report contains the text of the joint resolution of the legislature passed May 11, 1887, assenting to the act of Congress of March 2, 1887. The plan of organization adopted by the trustees March 21, 1888, after consultation with the president and secretary of the State Board of Agriculture, the State Horticultural Society, and the State Dairymen's Association, is given on pages 5-7. The outline of the plan for the work of the Station prepared by the Board of Direction March 28, 1887, is given on pages 7 and 8. The plan includes the following general lines of work:

- (1) The culture of the cereal grains and the grasses.
- (2) The feeding of animals with reference to growth and meat product.

(3) The feeding of cattle with reference to the milk product.

(4) Orcharding and the culture of small fruits and garden products.

The following is a list of experiments undertaken before June 30, 1887 :

Field experiments—

1. Corn, testing varieties.
2. Corn, testing varieties for ensilage.
3. Corn, time of planting.
4. Corn, depth of planting.
5. Corn, thickness of planting.
6. Corn, planting in hills or drills.
7. Corn, effect of depth and time of planting.
8. Corn, frequency of cultivation.
9. Corn, depth of cultivation.
10. Corn, effect of root pruning.
11. Corn, effect of fertilizers.
12. Oats, quantity of seed per acre.
13. Oats, compact or loose seed bed.
14. Oats, time of sowing.
15. Oats, depth of sowing.
16. Grasses, comparison of varieties.
17. Clovers, comparison of varieties.
18. Grasses and clovers sown with or without grain.
19. Grasses, field test of varieties.
20. Clovers, field tests of varieties.
21. Grasses and clovers, field tests of mixtures.
22. Weeds, numbers and kinds on given areas.
23. Rotation, university experiments continued.
24. Fertilizers, comparison of.
50. Grass and clover, effect of ripeness on yield and chemical qualities.
53. Wheat, effect of time and manner of harvesting.
54. Corn, root growth.

Feeding experiments—

25. Feeding ensilage to growing cattle.
26. Feeding cattle of different breeds.
27. Cost of production of young steers.
28. Cost of production of young colts.
29. Cost of production of young calves.
30. Effect of ash constituents upon pigs.
58. Record of milk product, milk measured in experiment No. 29.
59. Cost of production of young heifers.

Tree culture—

31. Orchard, soil cultivation and management.
32. Orchard, soil fertilization.
33. Apples, testing new varieties by planting.
34. Apples, testing new varieties by top-grafting.
35. Apples, testing hardiness of root-grafted and double-worked trees.
36. Pears, testing new varieties.
37. Plums, testing new varieties.
38. Cherries, testing new varieties.
39. Forest trees, growing of.
57. Orchard, investigation of soil moistures.

Vine culture—

- 40. Grapes, testing new varieties.
- 41. Grapes, methods of training.
- 42. Grapes, soil treatment.

Small-fruit culture—

- 43. Blackberries, testing varieties.
- 44. Raspberries, testing varieties.
- 45. Strawberries, testing varieties.
- 46. Strawberries, method of management.
- 51. Strawberries, raising seedlings.
- 52. Raspberries, soil management.

Gardening—

- 47. Tomatoes, effect of artificial fertilization upon earliness of product.
- 48. Beans, testing varieties.
- 49. Sweet corn, testing varieties.
- 56. Potatoes, investigation of scab.

Tree and vine culture—

- 59. Fungicides, use of.

Two of these experiments were carried through to completion before the date at which this report closes—June 30 ; of the others, no further account is given here, since the incomplete record of progress would be of little value ; they will be reported upon in full in the future publications of the Station.

Experiment No. 25 ; feeding ensilage to cattle.—This experiment was not entirely station work. But the silo had been filled in the summer of 1887 under the supervision of Professor Morrow and Mr. Hunt ; and the feeding, which had been begun in March, was taken up by the Station as soon as it was organized and by it carried on to the end of the experiment.

The duration of the experiment was from March 10 to April 30. Within this time some 17 tons of ensilage were fed to a mixed lot of cattle, which averaged thirty-seven head for the whole term of the experiment. Some were fed ensilage and straw ; some ensilage, straw, and grain ; some ensilage, hay, and grain. Five thoroughbred Short-horn heifers were fed upon ensilage and straw for a month, and then for two weeks upon ensilage alone.

A full report of this experiment, with a description of the silo and of the way it was filled, and an account of the condition of the ensilage when the silo was opened, may be found in Bulletin No. 2, issued by the Station in August, 1888. This bulletin gives also a comparison of the chemical composition of the ensilage and corn stover, and the results of a limited investigation of the biology of ensilage.

This experiment and the investigations conducted therewith are not regarded as exhaustive in any respect, and the subject will be considered further.

Experiment No. 54 ; corn, root growth.—In this experiment the number, length, and direction of the roots of the corn in four hills were ascertained, so far as possible, by digging a trench by the side of each hill and washing away the dirt from the roots with water. One hill was examined twelve, one twenty, and two twenty-six days after planting. A full report upon this experiment will appear in Bulletin No. 4.

INDIANA.

Agricultural Experiment Station of Indiana.

Department of Purdue University.

Location, La Fayette.

Director, Horace E. Stockbridge, Ph. D.

FIRST REPORT, 1888.

REPORT OF DIRECTOR (pp. 9-29).—*Experimental work prior to July 1, 1887* (pp. 9-12). During the past eight years a considerable amount of experimental work in chemistry, entomology, horticulture, and agriculture has been done by the professors of the University. Detailed accounts of what was accomplished prior to July 1, 1887, may be found in the following publications of the University:

SECOND ANNUAL REPORT:

1. Analysis of wood.—*Wiley*.
2. Milk analysis.—*Wiley*.
3. Soil analysis, Purdue farm.—*Wiley*.
4. Water analysis, Engine-house Well.—*Wiley*.

SIXTH ANNUAL REPORT.

5. Composition of the Sap of the Sugar Maple. Reprinted from Proceedings of American Association for Advancement of Science and from American Chemical Journal.—*Wiley*.
6. Optical Properties of Glucose.—*Wiley*.
7. Influence of Heating with Dilute Acids and shaking with Bone-Black on the Rotatory Power of Glucose.—*Wiley*.
8. Plan of Field Experiments in Agriculture.—*Ingersoll*.
Record of Meteorological Observations.—*Ingersoll*.

SEVENTH ANNUAL REPORT.

9. Cross-Fertilization of Corn.—*Ingersoll*.
Record of Meteorological Observations.—*Ingersoll*.

EIGHTH ANNUAL REPORT.

10. Estimation of Dextrose, Maltose, and Dextrine in Amylose.—*Wiley*.
11. Relation of Reducing Power, as Measured by Fehling's Solution to the Rotatory Power of Commercial Amylose.—*Wiley*.
12. Analysis of Mixed Sugars.—*Wiley and Crampton*.
13. Analysis of Fertilizers.—*Wiley and Spencer*.
14. Phosphoric Acid in Commercial Fertilizers.—*Spencer*.
15. Analysis of Sorghum Juices.—*Wiley*.
16. Clay Analyses.—*Wiley*.
17. Soil Analyses.—*Wiley and Peters*.
18. Record of Meteorological Observations.—*Ingersoll*.
19. Field Tests of Varieties of Sorghum.—*Ingersoll*.

SIXTH, SEVENTH, AND EIGHTH ANNUAL REPORTS.

20. Field Tests of Varieties of Wheat, Potatoes, Grapes, Small Fruits, and Fertilizers.—*Ingersoll*.

NINTH ANNUAL REPORT.

21. Report of State Chemist—Commercial Fertilizer Analyses.—*Wiley*. Reported by *Peters*.
22. Field Tests of Varieties of Wheat, Grapes, Small Fruits, and Fertilizers.—*Latta*.
23. Feeding Test of Cane Seed Meal.—*Latta*.

TENTH ANNUAL REPORT.

Report of State Chemist—Commercial Fertilizer Analyses.—*Warder*.

Record of Meteorological Observations.—*Ragan*.

MONTHLY BULLETINS—Meteorological Observations published since October, 1883.—*Huston*.

ANNUAL REPORTS 1876-1883—Experiments on Farm and in the Chemical Laboratory.—*Ingersoll, Latta, and Wiley*.

BULLETIN No. 1, December, 1884—Report on the Hessian Fly.—*Webster*.

BULLETIN No. 2, December, 1884—Report on Experiments with various Commercial Fertilizers on Corn and Potatoes.—*Latta*.

BULLETIN No. 3, April, 1885—Report on Insects affecting Growing Wheat.—*Webster*.

BULLETIN No. 4, September, 1885—Report on Experiments with Wheat.—*Latta*.

BULLETIN No. 5, November, 1885—Report on Experiments with Small Fruits.—*Troop*.

BULLETIN No. 6, March, 1886—Report on Experiments with Oats and Corn.—*Latta*.

BULLETIN No. 7, May, 1886—Report on Experiments with Oats and Corn.—*Latta*.

Notes on Commercial Fertilizers and Agricultural Chemistry.—*Warder*.

BULLETIN No. 8, August, 1886—Report on Experiments with Wheat.—*Latta*.

BULLETIN No. 9, October, 1886—The American Meromyza.—*Webster*.

BULLETIN No. 10, December, 1886—Report on Horticultural Experiment Stations.—*Troop*.

BULLETIN No. 11, May, 1887—Commercial Fertilizers.—*Warder*.

By an arrangement with the State Horticultural Society, made December, 1885, ten co-operative horticultural stations were established in various parts of the State.

Bulletin No. 10, published December, 1886, gives a detailed account of the operations of these stations for the year then ending. During the past three years seven co-operative stations for experiments in agriculture were established. The results of their work were recorded in Bulletins Nos. 8 and 12. Five stations have been established for investigations relating to the ravages of the Hessian fly.

Equipment of the Station (pp. 14-17).—An account of the equipment of the Station, illustrated with plans of the chemical laboratory and botanical rooms.

The Station is the headquarters of the State weather service, which includes between thirty and forty observing stations and about one hundred and forty flag stations. Monthly weather reports and weekly crop weather reports during the season are published and distributed.

The following bulletins were prepared in 1888:

BULLETIN No. 13, January, 1888—Report of New Organization.—*President Smart*.

BULLETIN No. 14, April, 1888—Report on Experiments with Oats and Corn.—*Latta*.

BULLETIN No. 15, June, 1888—Report Concerning the Potato Tuber.—*Arthur*.

BULLETIN No. 16, August, 1888—Report on Experiments with Wheat; Crop Rotations.—*Latta*.

BULLETIN No. 17, November, 1888—Report on Parturient Apoplexy.—*Hinebaugh*.

BULLETIN No. 18, January, 1889—Report on Experiments with Vegetables.—*Troop*.

BULLETIN No. 19, January, 1889—Report on Spotting of Peaches and Cucumbers.—*Arthur*.

BULLETIN No. 20, January, 1889—Report on Experiments in Cross-Fertilization, and the Culture of Tropical Ferns.—*Van Landeghem*.

The chemical department is making a complete soil analysis of the plats used for experimental purposes.

REPORT OF AGRICULTURIST, W. C. LATTA, M. S. (pp. 19-24).—The report covers the period from the organization of the Station under national authority, July 1, 1887, to January 1, 1889. The department has been chiefly occupied in conducting field experiments previously begun.

During the seasons of 1887 and 1888 experiments have been continued in testing varieties of wheat, oats, and corn; rates and dates of planting and seeding; methods of preparing the ground, and of planting, sowing, and cultivating; effect of previous manuring on yield of corn; effects on soil and crop of various systems of cropping without manures.

Arrangements have been made for new experiments on the field of about 12 acres, laid out in plats of one-tenth of an acre each. The report contains a plan of the campus and farm of the University, showing the buildings of the University and Experiment Station and arrangement of the fields devoted to experiments in agriculture; an account of the lysimeters belonging to the Station, illustrated with the ground plan and vertical section of the lysimeters and vault.

REPORT OF HORTICULTURIST ON THE CO-OPERATIVE HORTICULTURAL STATIONS, JAMES TROOP, M. S. (pp. 24-27).—This report includes a list of the plants and trees now on trial at the different stations, and a diagram of the horticultural experimental plat of 10 acres.

IOWA.

Iowa Agricultural Experiment Station.

Department of Iowa State College of Agriculture and Mechanic Arts.

Location, Ames.

Director, R. P. Speer.

FIRST ANNUAL REPORT, MARCH-DECEMBER, 1888.

REPORT OF DIRECTOR (pp. 5-13).

At the present time the Station has 65 acres of arable land in good condition for all kinds of crops.

It is a well demonstrated fact that the apples, pears, cherries, and plums which are adapted to the Atlantic States and western Europe are too tender in Iowa, except in specially favorable locations, as on river bluff soils, and the loess soils in the southwestern part of the State.

With a view to finding varieties adapted to the soil and climate of Iowa, the Station planted last spring an experimental orchard of 6 acres of apples, pears, cherries, and plums, which have proved hardy 400 miles east of Moscow, Russia, where the soils are somewhat similar to those of Iowa and the climate is colder, drier, and more changeable.

By a cross-fertilization of these Russian varieties and approved varieties grown in this country, it is hoped to obtain varieties peculiarly adapted to Iowa. A considerable number of field experiments were undertaken with grains, grasses, and garden vegetables. Six acres were seeded with alfalfa and four were planted with amber cane. Much damage was done to the grains and grasses by chinch-bugs, rust, and drought.

A large collection of the seeds of the most promising varieties of

natural grasses has been obtained from northwestern Iowa, Minnesota, Dakota, Idaho, and Colorado, with a view to determine whether any of them are more valuable for pasture and hay than tame grasses are. About two hundred separate stalks of amber cane were analyzed to determine their relative sugar content, and seeds from the stalks richest in sugar were planted in 1889. Results of experiments on corn tassels, silk, and blades are published in Bulletin No. 2, September, 1888. Samples of soils have been analyzed and chemical work done for the State Veterinarian and State Dairy Commissioner.

Experiments with arsenites as insecticides.—A series of experiments were entered upon for the purpose of determining whether or not white arsenic in solution can be profitably used as an insecticide. Its effect in varying strengths upon different plants and trees and upon leaf-feeding insects was carefully noticed. The conclusions reached were that white arsenic in solution can not be used stronger than 1 pound in 1,200 gallons of water without injury to foliage, and that this strength is too weak to kill quickly, if at all, the leaf-feeding larvæ.

Experiments were also conducted for the purpose of determining whether forcible spraying with London purple was more injurious than gentle spraying, but in no case was the damage worse in the former case than in the latter, if the leaves were in each case equally well treated upon both surfaces.

Chinch bug experiments and observations.—Many experiments were made for the purpose of determining the best methods of prevention and remedy; from which it was concluded that, with a proper knowledge of the habits of this insect and the methods for its destruction, the farmers can, through united action and at no great expense, keep the evil in check.

Chinch-bug disease.—The chinch-bug fungus, a species of *Empusa* that has been so prevalent in the West the past summer, appeared on the Station grounds in noticeable numbers early in August, and since then the bugs have almost entirely disappeared from our vicinity. Experiments proved that this disease could be readily spread when the necessary atmospheric conditions were present, and then only.

Future work.—The Station will give especial attention to dairy matters and to draining, subsoiling, green manuring, and rotation of crops.

LOUISIANA.

No. 1. Sugar Experiment Station, Audubon Park, New Orleans.

No. 2. State Experiment Station, Baton Rouge.

No. 3. North Louisiana Experiment Station, Calhoun.

Department of Louisiana State University and Agricultural and Mechanical College.

Director, William C. Stubbs, Ph. D.

FIRST ANNUAL REPORT, 1888.

REPORT OF DIRECTOR (pp. 3-14).—The report contains the act of the legislature of 1884, providing for the establishment of Agricultural Experiment Stations as soon as Congress should make provision for them; the resolution of the Board of Supervisors establishing the Stations, passed in April, 1887, after the governor had certified his assent to the act of Congress of March 2, 1887; the act of the legislature approved July 12, 1888, assenting to the act of Congress of March 2, 1887, and ratifying the action of the Board of Supervisors of the State University and that of the State Bureau of Agriculture; the resolutions

of the State Board of Agriculture, passed February 24, 1888, locating the Stations and outlining the plan for their organization.

Sugar Experiment Station (pp. 9, 10).

The Sugar Experiment Station, established by the liberality of the sugar planters of the State, has been in successful operation since 1835. Its great mission has been to investigate the successful growing of the sugar-cane and sorghum and their manufacture into sugar. It controls a tract of land of 200 arpents lying immediately on the banks of the Mississippi River, a few miles above New Orleans.

Its experiments are of a threefold character—field, laboratory, and sugar-house.

In the field numerous experiments are conducted to test manurial requirements and varieties of cane, sorghum, rice, corn, oats, and forage crops. Physiological and germination questions have also been tested experimentally, and the efficacy of different kinds of drainage is now a constant study. A plat of 2 acres has been so tile-drained as to enable the water coming from each tile to be separately caught and analyzed. This plat has been subdivided and upon each subdivision manures of different composition have been used and their loss by drainage determined through two years. In this way much valuable information has been obtained, which will form the basis of a bulletin in the future.

With the aid of the United States Government, the Station has received over seventy varieties of sugar-cane from different parts of the world. Forty-eight of these have been successfully propagated at the Station.

In the laboratory not only are subjects of practical and scientific interest to the Station investigated, but analyses of sugar-cane and its products, soils, and fertilizers are here made for the planters without charge. It, together with the sugar-house, serves also the valuable purpose of fitting young men for chemists in the sugar-houses of our State. So great was the demand for trained sugar chemists last year by our planters that the Station could not fill one-half the applications. This demand is yearly increasing, and the time is not distant when every sugar-house in the State will be under chemical control.

The sugar-house is equipped with all the necessary machinery for the manufacture of sugar. Last season a complete diffusion plant of fourteen cells—capacity 2 tons of cane per hour—with cutters, fans, and conveyers, was erected. A verticle double effect of 400 square feet of heating surface was also procured. In addition to above there is in the sugar-house a vacuum strike pan, a centrifugal, a mixer, clarifiers, settling tanks, open evaporators, filter press, sulphur machine, a three-roller mill, two boilers, one engine, and a hot room.

The season just past has been devoted to the extraction and manufacture of sugar from both sorghum and sugar-cane by the “diffusion process.” The storm of the 19th of August prevented the realization of our hopes with sorghum, but with sugar-cane our most sanguine expectations were surpassed. Yields of 225 to 251 pounds of sugar to the ton of cane were obtained throughout the season. Results with details are given in bulletins.

State Experiment Station (pp. 10, 11).—The State Experiment Station, founded in 1886 by the Bureau of Agriculture, has been greatly enlarged since the reception of the funds from the national Treasury. This Station is situated upon the bluff lands of the Mississippi River, just at the divide between the sugar and rice lands of South and the cotton lands of North Louisiana. The farm of 210 acres, situated on the banks of the river, just north of the city of Baton Rouge, is well adapted to the growth of general crops.

Upon this farm is erected a dwelling, a large barn, a stable, and other necessary buildings. Live stock of the most improved breeds and approved blood has been secured. Forage crops, grasses, and clovers are receiving large attention, while the truck industry, now on the increase around Baton Rouge, is sharing with field crops the area devoted to experimentation. An extensive orchard of large and small fruit, together with a vineyard of a number of varieties of grapes, are now growing nicely on this Station.

North Louisiana Experiment Station (p. 11).

The North Louisiana Experiment Station is located upon the tertiary hills of North Louisiana, and contains 330 acres of land. It has a two-story dwelling (eight rooms), a laboratory, a large barn, a commodious stable, a tool room, and necessary houses for employés. This land and these houses, together with four mules, were generously donated by the parish of Ouachita. This Station is primarily intended for the benefit of the small farmers of North Louisiana, and every indication points to the growing appreciation of this Station by those for whose benefit it was established. Improved stock of all kinds have also been introduced here. A large area has been devoted to small grains, grasses, and clovers. An experimental field of 30 acres has been carefully platted and will be devoted permanently to experiments in field crops.

Publications.

The demand for bulletins from the Sugar Experiment Station is very great in foreign countries, and already there are a large number of applicants, to whom these bulletins are regularly sent. Nineteen bulletins, covering a variety of subjects, have already been issued and several more are now being prepared for the press. At each Station a meteorological outfit is provided and daily records of the weather made.

MASSACHUSETTS.

Massachusetts State Agricultural Experiment Station.

Location, Amherst.

Director, Charles A. Goessmann, Ph. D.

SIXTH ANNUAL REPORT OF THE BOARD OF CONTROL, 1888.

REPORT OF DIRECTOR (pp. 7-10).—During 1888 the legislature passed two acts affecting the organization and work of the Station. The membership of the Board of Control has been increased, and the control of commercial fertilizers has been committed to the director of the Station under new regulations. The Station has also undertaken the chemical work for the Hatch Station. A department of vegetable physiology has been organized, and Prof. James Ellis Humphrey, a graduate of Lawrence Scientific School, Harvard University, and late professor of botany at the University of Indiana, has taken charge of this department.

The work of the year is classified as follows:

Feeding experiments.

- I. Experiments with milch cows; English hay, corn stover, fodder corn, ensilage, corn and cob meal, wheat bran, and gluten meal.
- II. Experiments with milch cows; green fodder, vetch and oats, Southern cow-pea, corn meal, wheat bran, and gluten meal.
- III. Experiments with pigs; skim milk, corn meal, corn and cob meal, gluten meal, and wheat bran.
- IV. On fodder supply and analyses of fodder articles.

Field experiments.

- V. Fodder corn raised with single articles of plant food.
- VI. Fodder crops raised with and without complete manure.
- VII. Experiments with vetch and oats, serradella, and Southern cow-pea.
- VIII. Experiments with potatoes, roots, and miscellaneous crops.
- IX. "Potato scab," by Prof. James Ellis Humphrey.

Work in the chemical department.

- X. Fertilizer laws and fertilizer analyses; miscellaneous analyses.
- XI. Water analyses.
- XII. Compilation of analyses of fodder articles with reference to food value.
- XIII. Compilation of analyses of fodder articles, with reference to fertilizing ingredients.
- XIV. Compilation of analyses of agricultural chemicals and refuse materials used for fertilizing purposes.
- XV. Meteorological observations.

FEEDING EXPERIMENTS (pp. 11-93).

I. *Feeding experiments with milch cows.*—*English hay, corn stover, fodder corn, corn ensilage, corn meal, corn-and-cob meal, wheat bran, and gluten meal* (pp. 11-37).

During the year 1886 a series of feeding experiments with milch cows was inaugurated for the purpose of comparing the feeding effects of dry corn fodder, of corn ensilage, and of corn stover, as a substitute in whole or in part for English hay; and that of corn ensilage, as compared with various kinds of roots, as far as practicable, under corresponding circumstances. The same variety of corn, if not otherwise specified, served for each trial. The corn ensilage used on these occasions has been produced in every instance from a corn crop of the same advanced state of maturity as the one which furnished the dry corn fodder, *i. e.*, at the beginning of the glazing over of the kernels.

The daily diet of the cows consisted, at the beginning of the experiment, of $3\frac{1}{4}$ pounds of corn meal, an equal amount of wheat bran, and all the hay they could eat. This combination of fodder articles was adopted as the basis of our investigation mainly for the reason that it had been used in some of our earlier feeding experiments, and not on the assumption of its being the best possible combination of fodder articles for milch cows. The actual amount of hay consumed in each case was ascertained by weighing out a liberal supply of it and deducting subsequently the hay left over. The statement made in our records in this connection refers to the average consumption of hay per day during the feeding period.

The temporary changes in the diet, whenever decided upon, were carried out gradually, as is customary in all carefully conducted feeding experiments. At least five days are allowed in every instance to pass by, in case of a change in the character of the feed, before the daily observations of the results appear in our published records. The dates which accompany all detailed reports of our feeding experiments, past and present, furnish exact figures in that direction. This is in particular the case whenever such statements are of a special interest for an intelligent appreciation of the final conclusions presented. The weights of the animals were taken on the same day of each week, before milking and feeding.

The valuation of the various fodder articles consumed was based on the average local market price per ton in Amherst, 1886-87:

Good English hay.....	\$15.00	Rye middlings	\$24.00
Corn meal.....	23.00	Dry corn fodder (stover).....	5.00
Wheat bran.....	20.00	Corn ensilage	2.75
Gluten meal.....	23.00	Carrots	7.00

1886.—From the description of our earlier feeding experiments with milch cows (see Fourth Annual Report, page 11), it may be observed that the relations of the digestible nitrogenous and non-nitrogenous organic constituents in the different combinations of fodder articles which constituted, during the various feeding periods, the daily diet of the cows, varied on that occasion from 1:6.7 to 1:10.17.

In 1887 the experiment was repeated with the same coarse fodders, but by the use of gluten meal the nutritive ratio was narrowed down to 1:5.9 to 1:7.9.

The results of the experiment led to the following conclusions:

The nutritive value of our dry corn fodder (stover) and of a good corn ensilage, taking into consideration pound for pound of the dry vegetable matter they contain, has proved in our case fully equal, if not superior, to that of the average English hay.

The nutritive feeding value of carrots, taking into consideration pound for pound of the dry vegetable matter they contain, exceeds that of the corn ensilage as an ingredient of the daily diet, in place of a part (one-half) of the hay fed. The conclusions thus far stated are in full agreement with those pointed out in our earlier experiments.

The influence of the various diets used on the quality of the milk seems to depend in a controlling degree on the constitutional characteristics of the animal on trial. The effect is not unfrequently in our case the reverse in different animals depending on the same diet.

The total cost of the feed for the production of milk is lowest whenever corn fodder or corn ensilage have replaced, in the whole or in part, English hay, under otherwise corresponding circumstances.

The net cost of feed consumed for the production of 1 quart of milk during the various feeding periods varies as widely as from .34 cent to 1.6 cents in the case of the same cow. The net cost of the feed is obtained by deducting 80 per cent of the value of the fertilizing constituents it contains.

The manurial value of the feed consumed during the entire feeding experiment, deducting 20 per cent for the amount of fertilizing constituents lost in the production of milk, is, at the current market rates, in every instance, more than equal to one-third of the original cost of the feed.

To avoid misconception regarding the statement of net cost of milk used in our description, I state once more that it does not include expenses of labor, housing, interest on investment, etc., but means merely net cost of feed after deducting 80 per cent of its manurial value. (For details see Fifth Annual Report, pages 11-34.)

1888.—To verify as far as practicable the above-stated conclusions, a new series of observations was decided upon. The course adopted was essentially the same as in the preceding year.

Six cows, grades, served in the experiment, which was subdivided into seven feeding periods. The nutritive ratio varied from 1:5.5 to 1:6.1. This experiment in the main fully sustained the conclusions drawn from the preceding ones.

The high nutritive value of fodder corn, good corn ensilage, and corn stover, as compared with that of English hay, counting in all instances pound for pound of dry vegetable matter, is fully confirmed. The general condition of the animals on trial, as well as the quality of the milk, point in that direction.

The daily yield of milk decreased gradually, apparently at a normal rate, during the progress of the experiment. The shrinkage in the yield of milk amounted, at the close of the trial, in the case of different cows of different milking periods, to from 1.6 to 4 quarts per day. The weight of the cows had decreased in three cases, and had increased in three.

The first cost of feed for the production of 1 quart of milk in case of the same cow is, as a rule, from one-half to 1 cent less per quart wherever fodder corn, corn ensilage, or corn stover has replaced in part or in whole the English hay. The first cost of feed for the production of 1 quart of milk differs, for obvious reasons, quite seriously in case of the same diet as far as different animals are concerned. This difference stands in a direct relation to the daily yield of milk; the less the latter, the higher the cost of the feed. A few results taken from our subsequent records may convey some more definite idea regarding this important circumstance:

Fodder rations:	Pounds.
Fodder corn	18 to 19
Corn-and-cob meal	3 $\frac{1}{4}$
Wheat bran	3 $\frac{1}{4}$
Gluten meal	3 $\frac{1}{4}$

	Daily yield of milk.	First cost of feed (per quart).	Net cost of feed (per quart).
	<i>Quarts.</i>	<i>Cents.</i>	<i>Cents.</i>
Daisy	17.5	1.01	.50
Melia	12.7	1.28	.66
Eva	6.1	2.64	1.39

Fodder rations:	Pounds.
English hay	20
Corn-and-cob meal	3 $\frac{1}{4}$
Wheat bran	3 $\frac{1}{4}$
Gluten meal	3 $\frac{1}{4}$

	Daily yield of milk.	First cost of feed (per quart).	Net cost of feed (per quart).
	<i>Quarts.</i>	<i>Cents.</i>	<i>Cents.</i>
Daisy	13.5	1.97	1.28
Melia	10.9	2.44	1.59
Eva	5.6	4.74	3.09

The net cost of feed is obtained by deducting 80 per cent of the commercial value of the fertilizing constituents it contains from its first cost. The manurial value of the feed consumed during the feeding experiments, after deducting 20 per cent for the amount of fertilizing constituents lost in the production of milk, is at current market prices in every instance more than one-third of the original cost of the feed.

A tabulated feeding record is given for each cow experimented with. The following table is a summary of these records:

May.

Total amount of milk produced during the above records (eighty-seven days)	quarts..	977.6
Total cost of feed per quart of milk produced	cents..	1.93
Manurial value left behind per quart of milk produced	do....	.73
Net cost per quart of milk produced	do....	1.20

Minnie.

Total amount of milk produced during the above records (eighty-seven days).....	quarts..	999.5
Total cost of feed per quart of milk produced.....	cents..	1.85
Manurial value left behind per quart of milk produced.....	do....	.70
Net cost per quart of milk produced.....	do....	1.15

Melia.

Total amount of milk produced during the above records (eighty-seven days).....	quarts..	1,098.3
Total cost of feed per quart of milk produced.....	cents..	1.70
Manurial value left behind per quart of milk produced.....	do....	.65
Net cost per quart of milk produced.....	do....	1.05

Eva.

Total amount of milk produced during the above records (seventy-four days).....	quarts..	460.4
Total cost of feed per quart of milk produced.....	cents..	3.42
Manurial value left behind per quart of milk produced.....	do....	1.31
Net cost per quart of milk produced.....	do....	2.11

Lizzie.

Total amount of milk produced during the above records (eighty-seven days).....	quarts..	787.8
Total cost of feed per quart of milk produced.....	cents..	2.34
Manurial value left behind per quart of milk produced.....	do....	.90
Net cost per quart of milk produced.....	do....	1.44

Daisy.

Total amount of milk produced during the above records (seventy-eight days).....	quarts..	1,265.3
Total cost of feed per quart of milk produced.....	cents..	1.36
Manurial value left behind per quart of milk produced.....	do....	.58
Net cost per quart of milk produced.....	do....	.83

Tables are also given showing the manurial value of food used for each cow, analysis of the milk of each cow, and the analysis of each kind of food used.

II. *Feeding experiments with milch cows* (pp. 38-52).

The preceding annual report contains a record of feeding experiments with milch cows, in which some noted green crops were used in place of English hay.

1887.—A mixed crop of green oats and vetch, of Southern cow-pea and of serradella served in that connection.

Five cows were engaged in the trial. Two cows were fed with a daily fodder ration consisting of corn meal, $3\frac{1}{4}$ pounds (2 quarts); wheat bran, $3\frac{1}{4}$ pounds (4 quarts); English hay, 20 to 25 pounds.

The excess of hay left over was weighed back, and subsequently deducted from the original quantity. Three cows received periodically the above-stated daily rations, and alternately the following: corn meal, $3\frac{1}{4}$ pounds; wheat bran, $3\frac{1}{4}$ pounds; English hay, 5 pounds; and as much of either green vetch and oats, green Southern cow-pea or green serradella, as the individual animal would consume. They consumed per day, on an average, from 64 to 65 pounds of green vetch and oats; of green Southern cow-peas, 96 to 97 pounds; and in case of green serradella, from 97 to 98 pounds.

The feeding of the green crop commenced in every instance with the beginning of the blooming period.

The feeding of the different green fodders, in place of three-fourths of the customary daily rations of English hay, gave, on the whole, very satisfactory results. For details, we have to refer to the Fifth Annual Report of the Station.

1888.—The experiment has been repeated with some modifications during the past season. A mixed crop of vetch and oats and one of Southern cow-pea were raised for that purpose. (See record of field C in this report.)

The quantity of green fodder fed at stated times is somewhat less in pounds than in last year's trial, on account of the addition of gluten meal to our last year's fodder ration.

The daily green fodder ration consisted of corn meal, $3\frac{1}{2}$ pounds; wheat bran, $3\frac{1}{2}$ pounds; gluten meal, $3\frac{1}{2}$ pounds; English hay, 5 pounds; and as much of vetch and oats or cow-pea as the animal would consume, which amounted, in the case of green vetch and oats, to from 54 to 68 pounds, and in that of green Southern cow-peas from 70 to 80 pounds.

The nutritive ratio of the green fodder diet was a closer one than on former occasions, varying from 1:4.5 to 1:5.5. The nutritive effect was very satisfactory, for the animals, without exception, maintained their original weight; the yield of milk was in every instance somewhat raised, and the quality of the milk was equal to the best, as far as one and the same animal was concerned.

Five cows, grades, were turned to account in the trial. The net cost of the feed for the production of one quart of milk was in most instances lower than in case of a whole English hay ration.

The cost of green fodder is based on that of hay, \$15 per ton, allowing 2 tons of hay, with 15 per cent of moisture, as the average produce of English hay per acre.

This mode of valuation has been adopted, as on previous occasions, on account of the entire absence of market prices, as far as green vetch, cow-pea, and serradella are concerned. These crops as a rule rank higher in the scale of an agricultural valuation than the meadow grass.

Valuation per ton of the articles of fodder used.

Corn meal.....	\$24.00	English hay.....	\$15.00
Corn-and-cob meal.....	20.70	Vetch and oats.....	2.75
Wheat bran.....	22.50	Cow-pea.....	3.14
Gluten meal.....	22.50	Rowen.....	15.00

Details of these experiments are given in tabulated form, as in the case of preceding ones.

The analyses of corn-and-cob meal and of English hay are the same as used in the preceding experiment.

The milk and creamery record of the Station farm from November 1, 1887, to October 31, 1888, is given in tabular form.

III. *Feeding experiments with pigs.*—*Skim milk, corn meal, corn-and-cob meal, wheat bran, and gluten meal* (pp. 53-83).

Our annual report for 1887 contains a description of seven successive feeding experiments with growing pigs, which were instituted mainly for the purpose of ascertaining the cost of the feed required for the production of a definite weight of dressed pork.

In the first and second cases, creamery buttermilk and home-made skim milk with corn meal had furnished the sole ingredients of the daily diet of the animals on trial; whilst, during the five succeeding ones, wheat bran and gluten meal had been added as fodder constituents. (For details, see Fifth Annual Report, pages 55-83.)

In comparing the final results of the different experiments from a financial standpoint, adopting in all cases, for obvious reasons, a corresponding local market value

of the fodder articles used, it was found that feeding skim milk or creamery butter-milk and corn meal in connection with wheat bran and gluten meal, as described in the Fifth Annual Report, experiments III, IV, V, VI, VII, had lessened the net cost of production of dressed pork.

This reduction appeared, however, to be due in a majority of experiments (III, IV, V, and VI,) rather to a higher commercial value of the manurial refuse resulting, than to a higher nutritive effect of the stated change in the character of the diet. The results obtained in the seventh experiment alone furnished an exception to this circumstance; for, in this case, the smallest quantity of the total weight of the dry feed consumed showed not only a high commercial value of the manurial refuse resulting, but also the highest nutritive effect. The subsequent reprinted summary of the seven experiments may serve as a further illustration of the previous discussion.

Summary of experiments.

[Based on the same cost of feed and manurial valuation of feed consumed.]

No. of Experiment.	II.	III, IV, V.	VI.	VII.
Average amount of dry matter for production of 1 pound of dressed pork.....pounds..	3.31	3.86	3.56	3.07
Cost of feed per pound of dressed pork.....cents..	5.51	5.92	5.69	5.15
Manurial value of feed per pound of dressed pork.....do....	2.30	2.91	2.78	2.52
Net cost of feed per pound of dressed pork after deducting 30 per cent from manurial value.....cents..	3.90	3.88	3.74	3.39

From the above summary it is apparent that the course of feeding adopted in the seventh experiment has given the most satisfactory pecuniary results; for the net cost of feed consumed amounted to 3.39 cents per pound of dressed pork produced, after allowing a loss of 30 per cent of the manurial value of the feed in consequence of the growth of the animal. As we sold our dressed pork for from $5\frac{1}{2}$ to $7\frac{1}{2}$ cents per pound, we received from 1.5 to 3.5 cents for labor, housing, etc.

The statement that an addition of gluten meal or of wheat bran, or of both, to a diet which previously consisted only of skim milk and corn meal, tends to increase the commercial value of the manurial refuse resulting, is based on the following considerations:

(1) The principal fertilizing elements contained in a mixture of equal parts of gluten meal and wheat bran have a higher market value than those contained in an equal weight of corn meal.

(2) It is admissible for mere practical purposes to assume that, in raising one and the same kind of animals to a corresponding weight, a corresponding amount of nitrogen, of phosphoric acid, of potash, etc., will be retained and stored up in the growing animal.

An excess, therefore, of any or of all the three essential fertilizing constituents previously specified in one diet, as compared with that of another one, counts in favor of that particular diet as far as net cost of feed is concerned.

The following abstract, taken from the details of the seventh feeding experiment in the Annual Report for 1887, will assist in explaining the conclusions drawn from the experiment, viz: Since the daily fodder rations in the experiments had consisted of the same kind of fodder ingredients and the same care had been taken at all periods of the experiments to attend to the call for food, the difference in results was largely due to a particular mode of combining at different times the same fodder ingredients to make up the daily diet:

Seven animals, crosses between White Chester and Black Berkshire, served in this experiment (VII). Their live weights were from 22 to 26 pounds. The same fodders

were used as in the third, fourth, fifth, and sixth experiments, but in different proportions. The daily ration of corn meal was gradually increased during the progress of the experiment, altering the relative proportion between the nitrogenous and non-nitrogenous parts of the feed from 1 : 2.9 until it reached 1 : 4.28.

Average of daily rations (experiment VII).

	Corn meal.	Skim milk.	Wheat bran.	Gluten meal.	Feed- ing pe- riods.	Nutri- tive ra- tio of food.
	<i>Ounces.</i>	<i>Quarts.</i>	<i>Ounces.</i>	<i>Ounces.</i>		
June 28 to July 11.....	8.00	4			I	1: 2.91
July 12 to July 25.....	12.00	6	.....	.....		
July 26 to July 28.....	12.00	6	1.34	2.66	II	1: 2.85
July 29 to August 8.....	12.00	6	2.00	4.00		
August 9 to August 15.....	14.67	6	2.66	2.66	III	1: 3.34
August 16 to August 23.....	17.34	6	5.33	5.33		
August 24 to August 29.....	20.00	6	8.00	8.00		
August 30 to September 12.....	23.34	6	11.35	11.35		
September 13 to September 26.....	29.00	6	17.00	17.00	IV	1: 4.28
September 27 to October 11.....	47.00	6	12.00	12.00		
October 12 to October 27.....	62.66	6	15.66	15.66		

Summary of experiment VII.

Mark of pig.	Corn meal.	Skim milk.	Wheat bran.	Gluten meal.	Live weight gained during experiment.	Dressed weight gained during experiment.	Cost per pound of dressed pork.
	<i>Pounds.</i>	<i>Gallons.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Cents.</i>
N.....	202.93	176.0	60.04	61.66	163.75	129.36	5.39
O.....	203.09	176.0	60.21	61.83	161.00	127.19	5.49
P.....	203.00	176.0	60.21	61.83	174.00	139.20	5.02
Q.....	194.09	173.0	57.71	59.93	164.50	128.31	5.27
R.....	194.43	173.0	58.04	59.66	177.50	138.45	4.89
S.....	194.43	173.0	58.04	59.66	162.50	128.38	5.26
T.....	194.43	173.0	58.04	59.66	178.25	140.85	4.80
	1,386.40	1,220.0	412.29	424.23	1,181.50	931.74	.....

Total cost of feed consumed during the above-stated experiment (1887).

1,386.40 pounds corn meal, at \$24 per ton	\$16.64
1,220 gallons skim milk, at 1.8 cents per gallon.....	21.96
412.29 pounds wheat bran, at \$22.50 per ton	4.64
424.23 pounds gluten meal, at \$22.50.....	5.77

Total 48.01

Average cost of feed for production of 1 pound of dressed pork, 5.15 cents.

Manurial value of feed consumed during the above experiment.

Corn meal	\$5.52
Skim milk	11.32
Wheat bran.....	2.97
Gluten meal	3.71

Total..... 23.52

Manurial value of feed for production of 1 pound of dressed pork, 2.52 cents.

The cost of feed consumed varied in case of different animals from 4.80 to 5.49 cents per pound of dressed pork produced.

Taking the entire lot of animals into consideration, it amounts to 5.15 cents per pound of dressed pork obtained. The amount of dry matter contained in the feed required for the production of one pound of dressed pork varied from 2.83 to 3.24 pounds.

Eighth feeding experiment.—The entire experiment was managed, as far as practicable, to serve as a repetition of our seventh feeding experiment. The substitution of the corn-and-cob meal of our own production from a superior home-raised corn for the clear corn meal of our general market may well be considered of but little consequence. This view is fully supported by a careful analysis of both.

The financial results of the eighth experiment, like those of the seventh, are superior to those obtained in the preceding five feeding experiments. This fact becomes still more worthy of notice when considering that the seventh experiment was carried on during a warmer period of the year and thus under more favorable circumstances than the eighth experiment. Our late results seem to confirm the conclusions arrived at in our previous experiments, namely :

(1) A gradual periodical change from a rich nitrogenous diet to that of a wider ratio between the digestible nitrogenous and non-nitrogenous food constituents of the feed is recommendable in the interest of good economy.

(2) The feeding effect of one and the same diet changes with the advancing growth of the animal on trial.

(3) The power of assimilating food and of converting it into live weight decreases with the progress in age.

(4) It is not good economy to raise pigs for the meat market to an exceptionally high weight. To go beyond from 175 to 180 pounds is only advisable when exceptionally high market prices for dressed pork can be secured.

Tables are given showing the estimated cost of feed used for the production of 1 pound of live weight during the succeeding stages of growth of the entire lot of pigs which served in the eighth experiment.

The net cost of feed consumed for the production of 1 pound of dressed pork, making a deduction of 30 per cent of the fertilizing constituents contained in the feed, varies in the case of different animals from 3.52 cents to 4 cents per pound. In the case of the entire lot of pigs it amounts to 3.83 cents per pound. As we sold our dressed pork at 7½ cents per pound, we secured 3.92 cents per pound for investment, labor and profit.

These estimates are based on the ruling local market prices of the time when the experiments were carried on. As these prices differ from those before used it is necessary for the purposes of comparison to re-adjust them by using values corresponding to those previously adopted.

The following is a summary of an experiment based on the same cost of feed and of the manurial value of feed consumed as used in preceding experiments :

Total cost of feed consumed during experiment.

1, 111.50 gallons skim milk, at 1.8 cents per gallon	\$20. 01
301. 56 pounds corn meal, at \$24 per ton	3. 62
298. 76 pounds wheat bran, at \$22.50 per ton	3. 36
373.28 pounds gluten meal, at \$22.50 per ton	4. 20
1, 098.26 pounds corn-and-cob meal, at \$20.70 per ton ...	11. 42
Total	42. 61

Average cost of feed for production of 1 pound dressed pork, 5.32 cents.

Manurial value of feed consumed during experiment.

Skim milk	\$10. 00
Corn meal	1. 20
Wheat bran	2. 02
Gluten meal	3. 26
Corn-and-cob meal	3. 33
Total	19. 81

Manurial value of feed for production of 1 pound of dressed pork, 2.48 cents.

The net cost of feed for the production of 1 pound of dressed pork, taking the entire lot of pigs into consideration, amounts to 3.69 cents. This result is the second best in our whole series of experiments. This fact becomes more significant when it is duly considered that the experiment (VIII) was carried out during the winter season.

Ninth experiment.—Six pigs of a mixed breed, weighing from 17 to 22 pounds each, served in the experiment. The feeding began April 12 and closed August 8. The live weights of the animals at the time of killing varied from 185 to 203.5 pounds. Skim milk, corn meal, gluten meal and wheat bran furnished the ingredients of the diet. The mode of feeding was practically divided into three periods, with reference to the nutritive character of the feed, as follows:

Period.	Live weight of animal.	Nutritive ratio.
	<i>Pounds.</i>	
First.....	20 to 90	1 digestible nitrogenous; 2.66 digestible non-nitrogenous constituents.
Second.....	90 130	1 digestible nitrogenous; 3.62 digestible non-nitrogenous constituents.
Third.....	130 200	1 digestible nitrogenous; 4.35 digestible non-nitrogenous constituents.

The details of experiment IX are given in tabular form. The following is a summary of the tables:

Summary of experiment IX.

	1.	2.	3.	4.	5.	6.	Total.
Corn meal pounds..	109.97	109.97	109.97	109.97	109.97	109.97	659.82
Skim milk gallons..	168.75	168.75	168.75	168.75	168.75	168.75	1,012.50
Corn-and-cob meal pounds..	118.69	117.66	118.69	118.69	118.69	118.69	711.11
Wheat bran do....	53.65	53.38	53.65	53.65	53.65	53.65	321.63
Gluten meal do....	70.38	69.32	70.38	70.38	70.38	70.38	421.22
Live weight gained during experi- ment..... pounds..	179.25	165.75	177.25	171.75	172.25	185.25	1,051.50
Dressed weight gained during experi- ment..... pounds..	144.65	135.63	143.61	140.36	140.47	153.39	858.11
Cost per pound of dressed pork ... cents..	4.83	5.13	4.86	4.98	4.97	4.56	.....

Total cost of feed consumed during the above-stated experiment.

659.82 pounds corn meal, at \$23 per ton	\$7.59
1,012.50 gallons skim milk, at 1.8 cents per gallon	18.23
711.11 pounds corn-and-cob meal, at \$20.70 per ton.....	7.36
321.63 pounds wheat bran, at \$23 per ton	3.70
421.22 pounds gluten meal, at \$24 per ton.....	5.05

Total 41.93

Average cost of feed for production of 1 pound of dressed pork, 5.15 cents.

Manurial value of feed consumed during the above experiment.

Corn meal	\$2.11
Skim milk.....	8.29
Corn-and-cob meal.....	2.16
Wheat bran	2.01
Gluten meal	4.05
Total.....	18.62

Manurial value of feed for production of 1 pound of dressed pork, 2.17 cents.

Summary of experiments (II to IX, inclusive).

[Based on the same cost of feed and manurial valuation of feed consumed.]

No. of experiment.	II.	III, IV, V.	VI.	VII.	VIII.	IX.
Average amount of dry matter for production of 1 pound of dressed pork	3.31	3.86	3.56	3.07	3.27	3.00
Cost of feed per pound of dressed pork	5.51	5.92	5.69	5.15	5.32	4.89
Manurial value of feed per pound of dressed pork	2.30	2.91	2.78	2.52	2.48	2.30
Net cost of feed per pound of dressed pork after deducting 30 per cent from manurial value	3.90	3.88	3.74	3.39	3.58	3.27

Cost of feed for the production of 1 pound of live weight during the different feeding periods.

Feeding period.	Live weight of animal at close of feeding period.	Gain in live weight during period.	Cost of feed for production of 1 pound of live weight.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Cents.</i>
1. First	50.00	28.50	1.72
Second	95.00	45.00	3.87
Third	140.25	45.25	4.13
Fourth	200.75	60.50	4.78
2. First	45.00	25.00	1.96
Second	88.00	43.00	4.05
Third	128.25	40.25	4.57
Fourth	185.75	57.50	5.03
3. First	44.50	25.50	1.92
Second	91.25	46.75	3.72
Third	132.00	40.75	4.59
Fourth	196.25	64.25	4.50
4. First	42.00	25.00	1.96
Second	85.25	43.25	4.02
Third	126.00	40.75	4.59
Fourth	188.75	62.75	4.61
5. First	45.00	23.50	2.09
Second	86.75	41.75	4.17
Third	129.50	42.75	4.38
Fourth	193.75	64.25	4.50
6. First	47.00	28.75	1.70
Second	95.00	48.00	3.63
Third	142.25	47.25	3.96
Fourth	203.50	61.25	4.72

ANALYSES OF FODDER ARTICLES (pp. 84-93).—This article includes tables of the analyses of the following fodders: Corn fodder (Pride of the North), corn cob (Pride of the North), corn-and-cob meal (Pride of the North), corn ensilage, corn meal, wheat bran, gluten meal, rowen, provender, ground oat feed, spent brewer's grain, cotton hulls, and cotton-seed meal.

FIELD EXPERIMENTS (pp. 97-152).

Fodder corn raised upon worn-out meadow lands, partly fertilized with one or two special articles of plant food, partly without the use of any manurial matter (pp. 97-106).

The observations recorded below extend already over a period of five years.* The field selected for the experiment was utilized for a series of years previous to 1882 as a meadow for the production of hay. The annual yield of that crop had suffered at that time a serious decline in quantity and quality. During the spring of 1883 it

* For details see preceding reports, 1883, 1884, 1885, 1886, 1887.

was planted in corn for the production of fodder corn, without the use of any manurial matter.

The same course of planting and of general treatment was carried out during the year 1884. The corn fodder raised in that year left no doubt about the serious exhaustion of the soil, as far as its fitness for a further successful cultivation of corn fodder was concerned, for the entire yield of that crop amounted only to 5,040 pounds per acre, with a moisture of 30 per cent. The soil had evidently reached a condition which promised to prove favorable for a special investigation, as far as the extent and the particular character of its exhaustion of plant food was concerned, whether the failure of the crop was due to a general exhaustion of essential articles of plant food or to that of any particular one of them.

As the cultivation of grasses and fodder corn affects the manurial resources of the soil in a similar direction, by abstracting approximately one part of phosphoric acid to four parts of potash, it seemed but natural that a soil which originally did not contain much more of available potash than of available phosphoric acid must become unproductive, as far as these crops are concerned, before the latter is exhausted. It is not less evident that a system of manuring, devised with reference to this circumstance alone, can prevent an early decline of remunerative crops in the majority of cases.

The recognized importance of both—grasses and fodder corn—in our present system of general farm management has served as the principal inducement to begin our field experiments at the Experiment Station with a practical illustration of the particular serious changes which a close rotation of these crops produces in the existing soil resources of plant food, wherever the adopted system of manuring does not provide for a periodical return of fertilizing substances, with reference to the kind and to the amount of each of them carried off by the crop.

The land set apart for the experiment consists of ten adjoining plats, one-tenth of an acre each in size. The plats are 5 feet apart; the grounds between them are kept free from any growth, and receive no fertilizing ingredients of any description. The entire field is surrounded by a tile drain, and each plat has a separate one through its center. This terminates at its east end in a well, which is connected with the surrounding drain.

The systematic treatment of the various plats began in May, 1885. All were plowed year after year, at the same time and in the same manner, in autumn after harvesting and in spring before manuring and planting. Plats 1, 3, 5, 7, 9, and 10 received annually for three succeeding years, 1885, 1886, and 1887, an addition of a definite amount of either phosphoric acid or of a nitrogen compound or of a potash compound, while plats 2, 4, 6, and 8 received no manurial matter during that period. All, except plat 6, were planted during the above-stated three succeeding years with the same variety of corn (Clark). Plat 6 received during that time no fertilizing material; it was plowed and worked with the cultivator in the same manner and at the same time when the other plats were thus treated; it was kept clear, as far as practicable, from every kind of vegetable growth (black fallow).

The details of the work and of the annual results of the course pursued in the management of the experiment have been described in the preceding annual report. The subsequent summary may suffice here to record the principal facts brought out before the beginning of the present year (1888).

FIELD A.

[1882, a meadow; 1883, planted with "Longfellow" corn; 1884, 1885, 1886, and 1887, planted with "Clark" corn.]

No. of plat.	Fertilizers applied.			Yield of dry fodder corn.		
	1885.	1886.	1887.	1885.	1886.	1887.
1.....	25 lbs. sodium nitrate (= 4 lbs. nitrogen).	50 lbs. sodium nitrate (= 7 to 8 lbs. nitrogen).	50 lbs. sodium nitrate (= 7 to 8 lbs. nitrogen) and 50 lbs. muriate of potash (= 25 lbs. potassium oxide).	Lbs. 480	Lbs. 430	Lbs. 720
2.....	Nothing	Nothing	Nothing	310	250	165
3.....	30 lbs. dried blood (= 4 lbs. nitrogen).	60 lbs. dried blood (= 7 to 8 lbs. nitrogen).	60 lbs. dried blood (= 7 to 8 lbs. nitrogen) and 100 lbs. dissolved bone-black (= 17 lbs. available phosphoric acid).	350	310	240
4.....	Nothing	Nothing	Nothing	300	250	130
5.....	25 lbs. ammonium sulphate (= 5 lbs. nitrogen).	50 lbs. ammonium sulphate (= 10 lbs. nitrogen).	50 lbs. ammonium sulphate (= 10 lbs. nitrogen) and 97 lbs. potash-magnesia sulphate (= 25 lbs. potassium oxide).	360	280	635
6.....	Fallow	Fallow	Fallow			
7.....	50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).	100 lbs. dissolved bone-black (= 17 lbs. available phosphoric acid).	100 lbs. dissolved bone-black (= 17 lbs. available phosphoric acid) and 50 lbs. muriate of potash (= 25 lbs. potassium oxide).	280	265	730
8.....	Nothing	Nothing	Nothing	250	195	165
9.....	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide).	50 lbs. muriate of potash (= 25 lbs. potassium oxide).	50 lbs. muriate of potash (= 25 lbs. potassium oxide).	945	840	655
10.....	48½ lbs. of potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide).	97 lbs. potash-magnesia sulphate (= 25 lbs. potassium oxide).	97 lbs. potash-magnesia sulphate (= 25 lbs. potassium oxide) and 60 lbs. dried blood (= 7 to 8 lbs. nitrogen).	845	895	940

A careful study of these results shows that neither phosphoric acid nor any form of nitrogen, when applied each by itself, even in exceptionally large proportions, has produced a material change in the annual yield as compared with that obtained on unfertilized plats. The application of potash compounds alone shows in every instance a decided increase in the crop. The annual yield was increased by its use during the first two years to twice the amount of that previous to its special application.

1888.—The original plan of the experiment has not been altered materially during the past season. The principal aim of our investigation has been the same as during the three preceding years; namely, to study the direction and the degree of exhaustion on plant food of field A during the progress of our investigation.

The results of the past season (1888) confirm the conclusion presented in our previous annual report, 1887. An exceptional deficiency of the soil on available potash, produced by continued close rotation of grasses and corn fodder, without any substantial provision for an exceptionally large consumption of potash, proves still the first cause of a reduced annual yield of corn fodder.

The exhaustion on available plant food assumes, however, as might be expected, a more general character as years pass on. This fact shows itself plainly in a gradual falling off of the annual yield on plat 9, where a liberal amount of potash as the sole fertilizing material exerted in preceding years a marked beneficial influence on the annual yield. The same circumstance causes evidently the lower yield upon those plats (1 and 7) which received a liberal manuring with potash compounds two years later, and, after a repeated application of each, phosphoric acid or nitrogen, had failed to improve the annual yield.

A manuring for three successive years with potash alone has sufficed in our case to terminate its beneficial effect on the natural productiveness of the soil, as far as the corn crop is concerned. More complete manures are required to restore a desirable degree of fertility of the soil.

The result obtained on plat 6 deserves a particular notice. This plat had been used, in common with the entire area occupied by our experiment, for two years in succession,—1883 and 1884,—for the production of fodder corn without the use of any manurial matter. The degree of exhaustion of the entire field was very marked and practically uniform. During the spring of 1885, when all other plats were planted with the same variety of corn, plat 6 was plowed and harrowed like the remainder, but not planted with corn; it was assigned to the task of ascertaining the effects of “black fallow” on the soil under treatment. Our observation in this connection confirms the results of more recent careful investigations into older systems of agricultural practice. Black fallow, as a rule, does not materially benefit the productiveness of an exhausted soil, and ought to be discouraged, therefore, from a mere financial point, at present rates of rent.

FIELD A.

[1882, a meadow; 1883, planted with “Longfellow” corn; 1884, 1885, 1886, 1887, and 1888, planted with “Clark” corn.]

No. of plat.	Fertilizers applied.		Yield of dry fodder corn.		Yield per acre.
	1887.	1888.	1887.	1888.	1888.
1.....	50 lbs. sodium nitrate (=7 to 8 lbs. nitrogen), and 50 lbs. muriate of potash (=25 lbs. potassium oxide).	50 lbs. muriate of potash (=25 lbs. potassium oxide).	Lbs. 720	Lbs. 617	Lbs. 6,170
2.....	Nothing.....	50 lbs. nitrate of soda (=7 to 8 lbs. nitrogen).	165	303	3,030
3.....	60 lbs. dried blood (=7 to 8 lbs. nitrogen) and 100 lbs. dissolved bone-black (=17 lbs. available phosphoric acid).	100 lbs. dissolved bone-black (=17 lbs. available phosphoric acid).	240	150	1,500
4.....	Nothing.....	Nothing.....	130	114	1,140
5.....	50 lbs. ammonium sulphate (=10 lbs. nitrogen), and 97 lbs. potash-magnesia sulphate (=25 lbs. potassium oxide)	97 lbs. sulphate magnesia.....	635	564	5,640
6.....	Fallow.....	Nothing.....		193	1,930
7.....	100 lbs. dissolved bone-black (=17 lbs. available phosphoric acid), and 50 lbs. muriate of potash (=25 lbs. potassium oxide).	50 lbs. muriate of potash (=25 lbs. potassium oxide).	730	676	6,760
8.....	Nothing.....	50 lbs. sulphate of ammonia (=10 lbs. nitrogen).	165	146	1,460
9.....	50 lbs. muriate of potash (=25 lbs. potassium oxide).	50 lbs. muriate of potash (=25 lbs. potassium oxide).	655	553	5,530
10.....	97 lbs. potash-magnesia sulphate (=25 lbs. potassium oxide) and 60 lbs. dried blood (=7 to 8 lbs. nitrogen).	97 lbs. potash-magnesia sulphate (=25 lbs. potassium oxide) and 100 lbs. dissolved bone-black (=17 lbs. available phosphoric acid).	940	737	7,370

Details of the field work and the condition of crops at different stages of growth are given in the report, together with the photographs illustrating some of the most striking features in the growth of plants on the different plats.

Influence of fertilizers on the quantity and quality of prominent fodder crops (pp. 107–113).

Field B.—The field assigned to the above-stated inquiry is located west of field A, and has been used, like the latter, for several years previous to the establishment of the Experiment Station for the production of hay. The land is nearly on a level,

and runs from north to south; it occupies at the present time an area of 1.7 acres. The soil consists of a somewhat sandy loam. During the spring of 1883 it was plowed and prepared for raising corn fodder. This crop was raised for one year in drills, and without the aid of any manurial matter. In 1884 the entire field was subdivided into eleven plats of equal size, with 5 feet of space between them. Every alternate plat has received from that date annually the same kind and same amount of fertilizer—600 pounds of ground bones and 200 pounds of muriate of potash per acre. The fertilizer has been applied at an early date each spring, either broadcast or between the rows, as circumstances admitted. It was in each case subsequently slightly harrowed under. Since 1885 all crops on that field have been raised in rows. The space between the different plats measured 5 feet. It has received thus far no manurial substance of any description, and is kept clean from vegetation by a proper use of the cultivator. Plats 11, 13, 15, 17, 19, and 21 are fertilized annually; plats 12, 14, 16, 18, and 20 have received thus far no fertilizer. The single plats are either occupied by one variety of plants or by two; in some instances several plats are used for one and the same crop. Corn and various prominent varieties of meadow grasses and of leguminous plants have thus far been selected for observation.

The subsequent tabular record of the crops raised upon the different plats of field B since 1884 may assist in a desirable understanding of its past history and its condition at the beginning of the season of 1888. The single plats are, since 1886, each 175 feet long and 33 feet wide.

Statement of crops raised on field B.

Plats.	1884.	1885.	1886.
11 (fertilized)....	{ Orchard grass (<i>Dactylis glomerata</i>)	Orchard grass	Orchard grass.
	{ Meadow fescue (<i>Festuca pratensis</i>)	Meadow fescue...	Meadow fescue.
12 (unfertilized) .	{ Orchard grass	Orchard grass	Orchard grass.
	{ Meadow fescue	Meadow fescue...	Meadow fescue.
13 (fertilized)....	{ Hungarian grass (<i>Setaria italica</i>)	Hungarian grass..	Hungarian grass.
	{ Pearl millet (<i>Penicillaria spicata</i>)	Pearl millet.	Pearl millet.
14 (unfertilized) .	{ Hungarian grass	Hungarian grass..	Hungarian grass.
	{ Pearl millet	Pearl millet.....	Pearl millet.
15 (fertilized)....	{ Timothy (<i>Pleum pratense</i>)	Timothy	Timothy.
	{ Redtop (<i>Agrostis vulgaris</i>)	Redtop	Redtop.
16 (unfertilized) .	{ Timothy	Timothy	Timothy.
	{ Redtop	Redtop	Redtop.
17 (fertilized)....	Corn (variety, Clark)	Corn	Corn.
18 (unfertilized) .	Corn	do	Do.
19 (fertilized)	do	do	Do.
20 (unfertilized) .	do	do	Do.
21 (fertilized)....	do	do	Do.

Plats.	1887.	1888.
11 (fertilized).....	Corn	Kentucky blue-grass.
12 (unfertilized) ..	do	Do.
13 (fertilized).....	{ Italian rye-grass (<i>Lolium italicum</i>)	Italian rye-grass.
	{ English rye-grass (<i>Lolium perenne</i>)	English rye-grass.
14 (unfertilized) ..	{ Italian rye-grass	Italian rye-grass.
	{ English rye-grass	English rye-grass.
15 (fertilized).....	Five varieties Southern cow-pea	Soja bean.
16 (unfertilized) ..	do	Do.
17 (fertilized).....	Meadow fescue	Meadow fescue.
18 (unfertilized) ..	{ Alsike clover (<i>Trifolium hybridum</i>)	Alsike clover.
	{ Medium red clover (<i>Trifolium pratense</i>)	Medium red clover.
19 (fertilized).....	{ Alsike clover	Alsike clover.
	{ Medium red clover	Medium red clover.
20 (unfertilized) ..	{ Mammoth red clover (<i>Trifolium medium</i>)	Mammoth red clover.
	{ Alfalfa or lucern (<i>Medicago sativa</i>)	Alfalfa.
21 (fertilized).....	{ Mammoth red clover	Mammoth red clover.
	{ Alfalfa	Alfalfa.

The weight of the hay obtained from the first cut of each kind of crop when well advanced in blooming gives a fair representation of their general character and con-

dition at the time of harvesting. The yield is in every instance stated with reference to an entire plat (175 by 33 feet).

	Fertilized plat.	Unfertil- ized plat.
	<i>Pounds.</i>	<i>Pounds.</i>
Grasses:		
English rye-grass, cut July 5, 1888	300	90
Italian rye-grass, cut July 5, 1888	260	105
Meadow fescue, cut July 2, 1888	700	No plat.
Leguminous plants:		
Medium red clover, cut July 5, 1888	690	250
Alsike clover, cut July 5, 1888	490	70
Mammoth red clover, cut July 5, 1888	460	20
Alfalfa, cut July 5, 1888	150	50
Soja bean (green),* cut August 30, 1888*	2, 080	1, 560

*The crop was put into a silo August 30, 1888.

Experiments with fodder crops for green fodder (pp. 115–120).—These experiments were a part of a series undertaken to test the adaptability of various fodder crops to the climate and soil of Massachusetts and to the needs of the dairy industry. The vetch, Southern cow-pea, and ser-radella have been thus experimented with by this Station for several years with marked success. “They yielded a liberal amount of green fodder from the beginning of June to the beginning of October.” (See Annual Report for 1887 (pp. 35–48) for an account of their value for milch cows.)

Experiments with potatoes (pp. 121–131).—(1) The influence of high-grade potash salts, muriate and double sulphate of potash and magnesia on the quantity and quality of potatoes. Experiments have been carried on since 1884 on the same plat. (2) Experiments with scabby potatoes, suggested by observations during the first experiment.

In 1886 the following conclusions were drawn in regard to the first experiment:

(1) Medium-sized whole potatoes give better results, as far as a large-sized, marketable crop is concerned, than half potatoes obtained from tubers of a corresponding size.

(2) Disregarding the results of the first year, when previously existing resources of plant food in liberal quantities must have rendered the influences of an additional supply of manurial substances less marked, it appears that sulphate of potash produced better results in our case than muriate of potash.

(3) The premature dying out of the vines, accompanied by blight or scab, or both, must be considered a controlling cause of an exceptionally large amount of small potatoes.

(4) Some peculiar condition of the soil upon the lands used for this experiment is to be considered the real seat of our trouble. (For further details, see Annual Report.)

In 1887 the experiment was a failure, owing to scab, wet, and heat, and in 1888, though means were taken to prevent the development of scab, on the theory that it was caused by a parasite in the soil, the results were discouraging.

Experiments to prove the cause of scab (pp. 126–130).—These experiments were begun in 1886. The results seem to show that scabby seed potatoes may produce, under certain circumstances, smooth and otherwise excellent potatoes, and that the origin and propagation of scab is

due to a peculiar condition of the soil. The report contains photographs of Beauty of Hebron, Early Rose, and Polaris seed potatoes raised from the scabby seed, and also of Colorado wild potatoes raised on the Station land.

Potato scab, Prof. J. E. Humphrey (pp. 131-139).—The article includes a short account of what was learned from the experiments on the prevention of potato scab and a résumé of the theories regarding this disease.

Experiments with root crops (pp. 139-149).—(1) Analysis of roots raised in 1887. (2) Description of the work carried on in the field with different varieties of roots valuable for feeding purposes. The following tables show the results of the experiments of 1887:

Statement of field results.

Name of variety.	Number of rows.	Number of roots.	Weight of roots.	Weight of three samples photographed.
			<i>Pounds.</i>	<i>Pounds.</i>
1. Mangel wurzel, Giant Long Red.....	2	150	365	11.75
2. Mangel wurzel, Yellow Ovoid.....	2	177	350	9.75
3. Beet, Eclipse.....	2	163	285	4.
4. Beet, Red Globe.....	2	173	335	7.5
5. Beet, Egyptian Turnip.....	2	146	170	8.75
6. Beet, Long Smooth Red.....	2	145	185	5.
7. Sugar beet, Saxony.....	2	144	314	8.75
8. Ruta-baga, White Sweet German.....	2	176	445	4.
9. Turnip, Early Yellow, or Golden Stone.....	2	43	50	5.5
10. Ruta-baga, Skirving's Purple Top.....	2	140	295	12.75

Root crops are commonly reported to contain on an average 35 to 45 per cent of their nitrogen in other and less valuable combinations than the typical albuminous matter or the genuine protein substances. The following are results of determinations:

Determination of albuminoid nitrogen in roots raised upon the fields of the Station.

Root No.	1	2	3	4	5	6	7
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Total nitrogen	1.20	1.61	1.53	1.90	1.20	1.81	1.25
Albuminoid nitrogen	0.58	0.55	0.56	0.57	0.58	0.51	0.60
Non-albuminoid nitrogen	0.62	1.06	0.97	1.33	0.62	1.30	0.65

The report contains notes on field observations during 1888 on different varieties of roots.

The seed was taken partly from our own imported stock of previous years, and partly chosen from varieties sent on by the U. S. Department of Agriculture at Washington, D. C.

The report contains photographs of different varieties of beets raised.
CHEMICAL DEPARTMENT (pp. 153-239).

(1) *Fertilizer laws and fertilizer analyses* (pp. 153-191).—The new State law regulating the sale of commercial fertilizers (approved May 3, 1888), which went into operation September 1, 1888, provides that all materials, single or compound, used for manurial purposes, without regard to source, when offered for sale at \$10 or more a ton, shall be subject to the

control of the Station. The official report of analyses is restricted to a statement of chemical analysis and such additional information as relates to the former, thus discontinuing the practice of affixing to analyses of fertilizers an approximate commercial valuation per ton of their principal constituents. The Station can only assume responsibility for analyses of samples collected by a duly qualified delegate of the Station, in conformity with the rules prescribed in the statute.

Tables showing in detail the results of analyses made at the Station during 1888 are given in the report.

(2) *Analyses of water* sent to the Station for examination, with tables (pp. 192-195).

COMPILATION OF ANALYSES MADE AT AMHERST, MASS., OF AGRICULTURAL CHEMICALS AND REFUSE MATERIAL USED FOR FERTILIZING PURPOSES, 1868-1889, PREPARED BY W. H. BEAL (pp. 196-219). This compilation does not include the analyses made of licensed fertilizers.

COMPILATION OF ANALYSES OF FODDER ARTICLES, FRUITS, SUGAR-PRODUCING PLANTS, ETC., MADE AT AMHERST, MASS., 1868-1889, PREPARED BY W. H. BEAL (pp. 221-239).

A. *Analyses of Fodder Articles* (pp. 222-225).

B. *Analyses of Fodder Articles with reference to Fertilizing Ingredients* (pp. 226-228).

C. *Analyses of Fruits* (pp. 229-233).

D. *Analyses of Sugar-producing Plants* (pp. 234-239).

METEOROLOGY (pp. 240-246).—The report contains summaries of the observations for 1888. The following is a record of the average temperature taken from weather records at Amherst, Mass., for three consecutive months during the summer and winter, beginning with the year 1836 :

December, January, February.		December, January, February.		June, July, August.		June, July, August.	
	<i>Degrees F.</i>		<i>Degrees F.</i>		<i>Degrees F.</i>		<i>Degrees F.</i>
1836-37.....	25.396	1862-63.....	27.640	1837.....	69.130	1863.....	66.656
1837-38.....	26.386	1863-64.....	26.060	1838.....	69.550	1864.....	69.336
1838-39.....	25.950	1864-65.....	21.310	1839.....	70.180	1865.....	68.946
1839-40.....	20.626	1865-66.....	25.676	1840.....	68.770	1866.....	67.400
1840-41.....	23.146	1866-67.....	25.276	1841.....	69.230	1867.....	67.920
1841-42.....	28.516	1867-68.....	20.350	1842.....	68.210	1868.....	69.700
1842-43.....	23.460	1868-69.....	26.290	1843.....	67.950	1869.....	66.890
1843-44.....	21.320	1869-70.....	27.866	1844.....	67.260	1870.....	71.700
1844-45.....	25.550	1870-71.....	26.666	1845.....	70.120	1871.....	67.810
1845-46.....	22.140	1871-72.....	24.630	1846.....	68.466	1872.....	70.790
1846-47.....	25.176	1872-73.....	21.350	1847.....	68.806	1873.....	68.596
1847-48.....	28.966	1873-74.....	27.286	1848.....	69.210	1874.....	66.306
1848-49.....	23.026	1874-75.....	21.180	1849.....	69.210	1875.....	68.026
1849-50.....	27.570	1875-76.....	28.156	1850.....	68.820	1876.....	71.780
1850-51.....	25.040	1876-77.....	23.510	1851.....	66.640	1877.....	70.080
1851-52.....	21.620	1877-78.....	28.506	1852.....	66.830	1878.....	68.896
1852-53.....	27.940	1878-79.....	24.290	1853.....	67.846	1879.....	68.150
1853-54.....	23.670	1879-80.....	30.506	1854.....	69.856	1880.....	69.286
1854-55.....	23.126	1880-81.....	21.856	1855.....	67.146	1881.....	67.966
1855-56.....	20.820	1881-82.....	29.256	1856.....	69.225	1882.....	69.866
1856-57.....	22.720	1882-83.....	24.220	1857.....	67.240	1883.....	68.840
1857-58.....	26.956	1883-84.....	26.506	1858.....	67.930	1884.....	68.960
1858-59.....	24.746	1884-85.....	22.630	1859.....	65.650	1885.....	66.740
1859-60.....	24.790	1885-86.....	24.846	1860.....	66.540	1886.....	66.100
1860-61.....	24.510	1886-87.....	22.146	1861.....	66.870	1887.....	68.100
1861-62.....	24.470	1887-88.....	20.827	1862.....	66.490	1888.....	67.893

The report contains photographs and plans of the chemical laboratory and farm buildings of the Station and maps of the land leased to the Station from the farm of the Agricultural College.

Hatch Experiment Station.

Department of the Massachusetts Agricultural College.

Location, Amherst.

Director, Henry H. Goodell, M. A.

ANNUAL REPORT, 1888.

REPORT OF DIRECTOR (pp. 3-8).—The report contains the text of the act of the legislature (approved April 20, 1887) assenting to the act of Congress of March 2, 1887. The Station was established by vote of the board of trustees of the college, March 2, 1888, and was at first called "The Experiment Department of the Massachusetts Agricultural College," but this name was subsequently changed to avoid confusion with the State Station already located on the college grounds. An agreement was made by which the State Station was to do the chemical work of the Hatch Station. The report also contains an outline of the work of the Station. Three bulletins were published during the year.

The subjects especially reported upon have been the best methods of protecting fruit buds from the extreme cold of our New England climate; the different kinds of fruit best adapted to our State; the effect of different fertilizing elements upon the time of maturing of crops; the results obtained from the use of various insecticides; illustrated descriptions of the beetle attacking corn, the jumping sumach beetle, the bud moth, the grape-vine leaf-hopper; and a discussion of bovine tuberculosis in its relations to public health.

REPORT OF ENTOMOLOGIST, C. H. FERNALD, PH. D. (pp 9-12 and 21-28).

(1) An account of the grain Aphodius (*Aphodius granarius* Linn.), with notes on a remedy found effective (p. 9).

(2) An illustrated account of the Jumping Sumach Beetle (*Blepharida rhois*, Forst.), not reported before from New England (pp. 10, 11). In Massachusetts they are very destructive to the Smoke-tree or Purple-fringe (*Rhus cotinus*). Remedies:

At first I tried hand-picking but soon found that this would cost more than the shrubs were worth. I then showered them with Paris green in water in the proportion of half a pound to 50 gallons of water, which quickly destroyed all the larvæ then on the shrubs. This remedy should be applied when the eggs first hatch, and again when the second brood appears. If rains occur it should be repeated.

(3) Notes on the Bud Moth (*Tmetocera ocellana*, Fab.), which was very abundant and injurious in 1888.

(4) Grape-vine Leaf-hoppers, natural history and remedies (pp. 21-23).

(5) Remedies for ants (pp. 23-25). Two experiments with carbolic acid were unsuccessful; one with kerosene was successful but killed the grass; two with bisulphate of carbon were unsuccessful; the sixth experiment was conducted as follows:

An ant hill nearly 6 feet square, next to the underpinning of a house, was doing much damage. The ground was so thoroughly mined that a person walking over it

would sink in quite deeply; the grass on the hill was nearly dead. With a small stick, holes about 6 inches deep were made 15 inches apart, over the hill, and two or three teaspoonfuls of the bisulphide poured into each hole, after which all the holes were closed up and the earth pressed down by stepping on them.

Result.—No ants have since appeared there, no fresh earth has been brought to the surface, and the whole place has formed a good turf.

It is probable that the method of treatment in this case is the explanation of its success.

(6) Alum as an insecticide for currant worms proved a complete failure (p. 25).

(7) Poisonous doses of insecticides and directions for treatment of persons poisoned (pp. 26-28).

REPORT OF HORTICULTURIST, S. T. MAYNARD, B. Sc. (pp. 13-21).—The students of the college are largely employed in the work connected with the experiments made by this department.

Tests of plant-bed cloth as a substitute for glass (pp. 13-15).

To determine its value, tests were made upon frames as nearly as possible of the same construction and exposure. The temperature was registered by Government standard soil thermometers placed within each bed.

The period of experiment covered quite a range of temperature, although at no time did it go below the freezing point. Careful observations, made later, when the temperature ran lower show the general results to be the same.

The conclusions reached are:

- (1) That the glass gives the greatest amount of protection from the cold.
- (2) That the heat accumulates most rapidly under glass when the sun shines, and is best prevented from escaping from the heating material in the bed at night.
- (3) That there is less danger of injury from sun-burning, and of a too great accumulation of heat with the cloth than with glass, and consequently less care is needed in using beds covered with this material during the day. At night, however, more protection is needed to keep out the cold.

In our experience the cloth sash is especially valuable for beds of recently transplanted plants, as the light is less intense and the evaporation less than with glass.

The cloth frame may be made at a cost of one-sixth that of glass.

Tables are given, showing the details of the experiments.

Experiments to find some practical method of protecting peach-buds from injury by cold (pp. 15-17).

- I. (1) In the fall of 1886 trees were laid down upon the ground and covered with soil, by first loosening the roots on one side and carefully bending those on the other.
- (2) The branches were drawn together and tied (1) without covering, (2) with a covering of pine boughs, (3) with a covering of strong matting.

Result unsatisfactory.

- II. Early in December, 1887, two trees were syringed with, first, a solution of glue; second, turpentine; third, turpentine and benzine; fourth, benzine and rosin; fifth, benzine and hard oil finish; sixth, linseed oil and turpentine.

Result.—All the trees except those treated with glue, linseed oil, and turpentine were killed. The trees treated with linseed oil and turpentine were badly injured, but are now making a good growth. The tree treated with glue was wholly uninjured, but showed no more fruit-buds than those unprotected.

- III. On a single tree with a large number of fruit-buds three branches in nearly the same condition were treated with the following materials applied with a brush: First, linseed oil; second, linseed oil and turpentine; third, linseed oil and benzine; fourth, benzine and rosin; fifth, shellac; sixth, glue.

Result.—In March it was found that the buds covered with linseed oil, shellac, and glue were apparently uninjured, but as the season advanced it was found that the turpentine and benzine had been applied to branches near the trunk and had spread over it so much as to kill it, consequently those buds which seemed uninjured failed to start.

Girdling crab-apple trees to hasten fruitfulness (pp. 17, 18).

Four trees of the same kind were selected and covered with straw matting. After the mat was bound about the tree, dry sawdust was poured in at the top of one, moist sawdust into another, and coal ashes into another, and the fourth contained nothing. After tying up the end of the mats, the whole was supported by two strong stakes.

Result.—The trees covered and protected with dry sawdust show more uninjured fruit-buds than those covered in other ways or unprotected.

The trees protected with wet sawdust and ashes showed no more uninjured fruit-buds than the same kinds unprotected.

Girdling the grape-vine to hasten ripening of fruit (pp. 18, 19).

Cutting rings of bark from the canes of the grape-vine to hasten the time of ripening has been practiced more or less for many years to prepare large specimens for exhibition, but only for the few years past has it been practiced to hasten the crop for market.

In a series of experiments made in the college vineyard in 1877 and 1878, and recorded in the Report of the Board of Agriculture of Massachusetts of 1878 and 1879, it was found that removing a ring of bark early in July, one-quarter of an inch wide, resulted in hastening the time of ripening from one to two weeks.

It was also concluded from very careful tests made at the time that the increased size and early maturity was not at the expense of the quality, and that as far as could be determined at that time, and which further observations have confirmed, that the vines are not materially injured by the girdling.

Girdling has been practiced in the college vineyard more or less every year since with favorable results. The canes that are to be cut away at the fall pruning only have been girdled, to avoid any possibility of injury to vine or root from stopping the downward flow of sap by the girdle.

Some seasons the results of this practice have been more marked than in others, but generally the increased price obtained for the early fruit has much more than paid expenses of the work, and in seasons of early frost, to which many sections of New England are liable, it has made the difference between total failure and fair profit.

To save expense in the work for the past two years the girdling has been done by twisting a wire very firmly about the canes the last of June above the point where the cane is to be cut away at the fall pruning.

About No. 20 wire has been found best, and results obtained have been more satisfactory than when the wires were put on the last of June or early in July and twisted very firmly about the cane.

Conclusion.—While we have no proof that the vines are in any way injured (notwithstanding that we have made very careful observations for many years), we would not advise girdling the entire vine, but would treat only those canes to be cut away at the fall pruning, and would leave about one-half of the vine to grow to a natural condition.

To protect trees from mice (pp. 19–21, and 47–48).—The composition of the remedies used in three experiments are given in the report.

Report on the new and standard varieties of fruit on the college lands (pp. 28–43.)

Field experiments (pp. 43–46).—To test the effect of the various essen-

tial elements of plant food, with peas, cabbages, raspberries, potatoes, blackberries, and beans. Tables are given showing results.

Pot experiment with a liquid plant food called "Flora Vita" on Bon Silence rose-bushes (p. 47).

Conclusions.—(1) That the liquid called "Flora Vita" gave as good growth as the ordinary liquid manure. (2) That the roses potted in a soil composed largely of sand made as good growth and gave more buds than those in soil with little or no sand in it.

MICHIGAN.

Experiment Station of Michigan Agricultural College.

Department of Michigan Agricultural College.

Location, Agricultural College.

Director, Edwin Willits, M. A.

FIRST ANNUAL REPORT FOR THE YEAR ENDING JUNE 30, 1888.

REPORT OF DIRECTOR (pp. 10-13).—The report contains a list of subjects for experiment suggested as important for the agriculture of the State, by the officers of the several departments of the Station, and an account of the problems connected with the extensive pine barrens of the State.

WHAT SHALL OUR STATIONS DO?

Preliminary to the organization of our Station, while waiting for the appropriation, the director called upon each professor of the college for a detailed statement of what he would like to do or have done in his division of the department to be organized, and they reported substantially as follows:

DR. R. C. KEDZIE, IN CHEMISTRY AND METEOROLOGY,

desired specially to conduct some analyses of ensilage corn, etc., at various stages of maturity, to test its value as a food for animals; also to continue his experiments relating to inert nitrogen; also his research as to the effect of tile draining on rain-fall and drought; and finally to have leave to conduct experiments on the pine barrens of Michigan, to be referred to hereafter.

PROF. A. J. COOK, IN ENTOMOLOGY,

made the following desirable points:

(1) Work out full life history of noxious insects, now known but imperfectly understood; to study the natural history and habits of new enemies as they appear from year to year.

(2) Experiment with insecticides and methods to prevent insect destruction.

(3) To study beneficial insects, with a hope to increase their value.

(4) To develop a race of superior bees by careful crossing and selection.

(5) To experiment as to bee forage in the hope of discovering plants that will insure a honey harvest at all dates and all seasons.

(6) To study bee enemies with the aim of discovering remedies.

(7) To investigate fungoid diseases of bees and other insects, in the hope to remedy the one and to make useful the other.

(8) Investigation of any practical question relating to insects, as bees *vs.* grapes, etc.

DR. W. J. BEAL, IN BOTANY AND FORESTRY.

Proposed experiments with grasses.

- (1) Test in small plats, on soils wet and on soils dry, say 6 feet square, all sorts of grasses (and other forage plants) from all sources, excepting some which have been tested and found of no value.
- (2) Test in larger areas, say 20 feet by 160 feet or larger, those sorts which seem to be promising, each species by itself.
- (3) Test a mixture of several of the most promising to compare the results with each sown alone. Perhaps more than one combination.
- (4) In one or more places sow an acre or more of a very large number of mixed grasses in drills, 3 or 4 inches apart, and hoe till well established and then watch the changes for some years.
- (5) Plant together a mixed lot of grasses which produce rootstalks, *Poa pratensis*, *Agropyrum repens*, *Cynodon dactylon*, *Agrostis vulgaris*, etc., and watch the strife and success of each.
- (6) Sow grass seeds in autumn and others in spring on good and on poor land without any other crops, to watch progress.
- (7) On some old pastures sow seeds of other grasses.
- (8) Mow one or more plats of permanent grass land six or more times a year, and one or more newly seeded. Analyze same.
- (9) Mow some plats and keep short all the time in imitation of a closely overfed pasture. Mow others less frequently and less closely, in imitation of a pasture in good condition, to see what will be the difference in productiveness and value.
- (10) Try to improve one or more sorts by selecting and cultivating.
- (11) In most or all cases weed the species while young. In most or all cases sow in close drills. Plats of grasses should not be nearer than 20 feet or more of each other on account of the very great difficulty of preventing the mixing. Other crops could be grown between the plats.
- (12) Recommend grass stations in Michigan, Nebraska, Arizona, Mississippi, and perhaps other places.
- (13) A careful study of these will soon lead to other experiments not here mentioned or here foreseen.

Proposed experiments in forestry.

- (1) Introduce a very much larger number of species from every part of the world when there appears to be any prospect of success.
- (2) Plant 10 acres with promising mixtures of trees for raising valuable timber; several mixtures, including white oak, white ash, shagbark hickory, white pine, the locust, catalpa, and some shade-enduring trees or shrubs mixed in to shade the ground and keep out the grasses.
- (3) On the sandy plains, as in Crawford County, in northern Michigan, study and plant all promising trees and forage plants.
- (4) On the plains plant 10, 20, or more acres to trees.
- (5) Further than the above I am not prepared to specify, but much other work is in contemplation. Most of this, however, would not require tree planting (additional) but would be in the nature of study and laboratory work.

A few other promising experiments.

- (1) Attempt to select and improve red clover.
- (2) Further experiments to test the effect of bumble bees on the yield of red clover.
- (3) Crossing a number of cultivated races of plants with foreign stock. (See Beal's Grasses, p. 308.)
- (4) Study the structure and physiology of grasses.
- (5) Study species of grasses as growing and preserved.
- (6) Improve wheat by selection, cultivation, and perhaps by cross-breeding.

(7) Study some injurious fungi and search for remedies.

(8) *Seed testing*.—We have laws to regulate the sale of fertilizers, why not for the sale of seeds as to purity and vitality? Have a law making seeds subject to inspection, the seller to guarantee to a certain standard. The Royal Agricultural Society of England has a consulting botanist who has done much good. His duties are largely increasing. As a country grows older this becomes more and more necessary to insure good seeds. (See Beal's Grasses, p. 206.)

PROF. SAMUEL JOHNSON, IN AGRICULTURE.

(1) Continue the feeding from calfhood to maturity of steers of the different breeds of cattle, under the same conditions, embracing accurate records of kind and amount of food consumed, weights each month, etc., to ascertain (1) the comparative growth of animals of different breeds (2) the cost per pound of beef of different breeds. This should be carried on or repeated with at least three different lots of steers.

(2) The feeding of sheep of different breeds in a similar manner to steers.

(3) The feeding of swine of different breeds.

(4) The growing of the grasses and clovers, on sufficient acreage, to test their value in practical feeding as well as by chemical analysis.

(5) The testing of a limited number of new varieties of grains and vegetables, etc., for a sufficient length of time so as to be able to speak with some certainty of their adaptation or otherwise to our latitude and agricultural conditions.

(6) Field experiments embracing (a) different methods of preparing soil for crops; (b) the implements best adapted to the work; (c) results from different amounts of seed; (d) results from different methods of cultivation; (e) testing of various fertilizers with different methods and times of application.

DR. E. A. A. GRANGE, IN VETERINARY SCIENCE.

(1) To spay heifers to test the effect on growth and feeding qualities.

(2) To spay cows while in milk to test length of time the milk would continue, and its amount and quality.

(3) To experiment on horses afflicted with heaves.

(4) To study the "germ theory" with relation to contagious diseases of animals, and to experiment as far as possible with the contagious diseases with reference to their cure and their transmission to other animals.

PROFESSOR BAILEY, IN HORTICULTURE,

in behalf of the State Horticultural Society, presented the following points, in the main formulated by him:

Recognizing the fact that Michigan is one of the leading States in all matters pertaining to horticulture, and appreciating the demands for horticultural experiment made by a very large population directly employed in growing fruits and vegetables, we respectfully ask that the State Board of Agriculture devote to horticultural experimentation its full proportion of the means to be derived from the operation of the Hatch bill. We recommend that land be procured where fruits and other objects of experiment shall be entirely free from molestation. It occurs to your committee that the horticultural experiments should embrace the following subjects:

(1) Experiments to originate new varieties of fruits, vegetables, and ornamental plants (a) by ordinary seedage; (b) by selection; (c) by crossing and hybridizing.

(2) Improvement and maintenance of old varieties (a) by methods of tillage; (b) by use of various fertilizers; (c) by changing of stock, crossing, and hybridizing.

(3) Introduction and testing of new varieties and species; (a) domestic cultivated plants; (b) wild fruits and ornamental plants; (c) Japanese and Chinese plants; (d) Russian plants.

(4) General physiological researches, including influence of pollen, stock and scion, laws of growth and development, etc.

(5) Pathological researches, or investigations concerning diseases of plants, especially peach yellows, rotting of plums and cherries, apple scab, tomato rot, potato rot, blackberry and raspberry rust, strawberry rust, grape rots and mildew, gooseberry mildew.

(6) Tools and manipulations.

For the purpose of carrying out systematic and continuous investigations upon plant diseases, we recommend that an expert be permanently employed for this purpose.

THE DAIRYMEN'S ASSOCIATION

of Michigan, who, through its president, Hon. George B. Horton, a member of our board, put in a claim for recognition in experiments in butter and cheese-making, and in testing the dairy value of different kinds of feed and the various breeds.

A glance at the foregoing will satisfy the most incredulous of the importance of the new development of our work, and further that no one station can take up and follow to a satisfactory conclusion more than one-tenth of the topics suggested. It was apparent that we should select what we could best do, and limit ourselves as near as may be to the work selected.

THE PINE BARRENS.

In addition to the subjects above detailed, we have in this State a special matter of grave public consideration, to wit, the Pine Barrens, so called. A large portion of the lands in fifteen counties in the north half of the lower peninsula is composed of a light sand, which has the repute of being infertile. In fact, repeated attempts to bring them into successful cultivation, in some localities, have been failures, while in other localities the success has been so moderate as to discourage settlement. When we consider the large area, which is not less than 5,000 and may reach 10,000 square miles, the problem of their restoration to agricultural possibilities is well worth the amplest expenditure and the most serious consideration. Here is a region as large as the cultivated portion of the valley of the Nile, which for thousands of years has supported a population of six millions, and was for ages the granary of the Roman Empire, abandoned by many to hopeless sterility. The Agricultural College has for years thought there is hope for the redemption of these lands, and, upon the passage by Congress of the experiment-station appropriation, proceeded at once to the consideration of the problem. We have established five stations, the central and largest at Grayling, Crawford County, and four smaller and in a sense subordinate ones, one at Walton, Grand Traverse County; one at Baldwin, Lake County; one at Harrison, Clare County, and one at Oscoda, Iosco County. The general station at Grayling was selected for the reason that it was thought to be, on the whole, the locality that would best represent the average—neither the best nor the poorest of the sterile land—and being in the highest altitude it would contend with one of the prime difficulties, that is, the climate. The difficulties are two; the first, the fact that frosts come late in the spring and early in the fall; the other, the fact that there is but little vegetable matter in the soil. In some localities the fires have burned it all up; in others, notably where pine has grown almost exclusively, there has but little accumulated. It has been demonstrated beyond cavil that the soil responds readily to manure and fertilizers; but it is manifest that in the first instance it will be utterly impracticable to purchase fertilizers for fifteen counties, and that the early redemption must consist in finding a grass that will grow and thereby increase the fertility from the soil itself and from the atmosphere.

The first problem, then, is to find the grass best fitted for the locality; this will furnish food for stock, and in time the problem will solve itself. To this end the college accepted the donation of the Michigan Central Railroad Company of 80 acres of wild land adjoining the village of Grayling. The whole has been fenced and 40 acres cleared, and the plans for the experiment will more fully appear in the bulletin of Dr. Kedzie, who has the principal charge of the Grayling station.

Near this tract 5 acres of old subdued land have been rented, upon which small plats of nearly one hundred varieties of grass have been seeded. The botanical department of the college, in charge of Dr. Beal, is gathering from all parts of the world grasses indigenous to those regions; from Siberia, China, Japan, Europe; from Brazil, the Argentine Republic, Chili, and Patagonia, in South America; also from Mexico and our Western plains, so that in the near future the department expects to have in cultivation on the plats at the college and the stations at the north part of the State nearly three hundred varieties.

The substations at Walton, Baldwin, Harrison, and Oscoda comprise each from 5 to 10 acres, and they will be used for seeding fewer of the grasses in larger areas, so as to test in more than one locality and under different conditions the growth of grasses on a larger scale. At Oscoda and Harrison experiments in forestry have also been added. At Grayling the larger forestry work will be made this year, six thousand five hundred trees of seventy-five varieties having been planted.

I need hardly say that the experiments are commanding the lively attention of the residents of the northern part of the State. After the pine, what?

CONCLUSION.

I can only add that each officer of the Station entered upon his line of work with a zeal which is an augury of success. In large measure many of the experiments taken in charge by the Station had been anticipated by the college, and their transfer to the "Station" enables us to proceed at once to the work assigned to us. Still the intervening months since the organization have been essentially devoted to preparation, and our reports must be more meager than those will be which are to follow.

REPORT OF CHEMIST, R. C. KEDZIE, M. D. (pp. 21-36) and (pp. 79-83—Bulletin No. 37, June, 1888).—Experiments have been begun to determine whether there is good reason to believe that tile-draining has an influence in augmenting floods and aggravating droughts.

Two sets of soil thermometers, to measure the temperature of the soil at 3, 6, 9, 12, and 24 inches below the surface, have been put in position and observations are taken three times a day. One set is located at the college and the other at Grayling. Observations on sun and shade temperatures; temperature of water in a river on the first day of the month from April to November, to measure the progressive march of the season; sunshine records; and other meteorological observations are recorded.

The sampling and analyzing of commercial fertilizers has been systematically carried forward. Most of the manufacturers cheerfully comply with the law, and protect their agents by paying promptly the fee necessary for a permit to sell. The report contains tables of results of analyses of commercial fertilizers for 1888, and of soil temperatures recorded at the college and at Grayling from May 1 to September 30, 1888.

Bulletin No. 37, reprinted on pp. 79-83, gives a preliminary account of the substation at Grayling, on the Pine Barrens, and of the field experiments with fertilizers thereon.

The problem, briefly stated, is this: With a light sandy soil of very porous quality, in a northern climate subject to late frosts in spring and early frosts in autumn, and liable to midsummer drought, with no fertilizers except marl, salt, and plaster, can any methods of tillage or kinds of crops bring these plains into profitable cultivation for ordinary farming, stock-raising, or fruit production?

With what the soil now contains, and what plants may accumulate from the rain and air and return to the soil when plowed under for green manure, and with the aid of the cheap mineral manures so abundant in this State, can we bring these sandy soils into profitable cultivation?

The experimental farm.—The tract of land donated for this purpose is described as the west half of northeast quarter of section seventeen, town twenty-six north, of range three west.

It is characteristically jack-pine plains, the timber being mostly *Pinus banksiana* or "jack pine," some scattering trees of Norway pine, scarlet oak (dwarf), huckleberry bushes, dwarf cherry, sweet fern, trailing arbutus, and many wild grasses (sedges). The ground is nearly level; the fire has run over most of it at frequent intervals, but the central part less than the north and south ends. The farm, both as to soil and the natural products growing on it, is considered a fair average of the jack-pine plains. It nearly touches the railroad at the southwest corner, and the experimental field of 20 acres at the south end of the farm is plainly visible from the car windows. The experimental field of 20 acres at the north end of the farm adjoins the village of Grayling. This field is nearly ready for seeding.

The mechanical treatment of the soil was considered very important from the conviction that the loose and porous condition of this soil is often the cause of failure in crops. Twenty plots of 1 acre each were separately seeded. The plats run north and south in the field, being nearly 4 rods wide and a little more than 40 rods long.

These twenty plots are cultivated with twenty kinds of grasses and other forage crops, including clovers, vetch, alfalfa, spurry, buckwheat, rye, and peas.

The field was divided across the plots into five nearly equal zones for testing the influence on all the plants used of certain manurial matters. The south zone was treated with marl from a lake near by, using 6 tons to the acre, which was incorporated with the soil by harrowing and rolling. To the next zone plaster was applied at the rate of 200 pounds to the acre; to the next zone 200 pounds of plaster and 200 pounds of common salt; to the fourth zone 200 pounds of salt, and the last zone received no manure, for purposes of comparison. It will thus be seen that there are one hundred separate experimental plots of one-fifth of an acre each in this field.

REPORT OF ENTOMOLOGIST, A. J. COOK, M. S. (pp. 37-42, illustrated) and (pp. 89-105—Bulletin No. 38, September, 1888).—(1) Notes on the weevil or snout beetle (*Anthonomus musculus*, Sag.), a new enemy to the strawberry. (2) *Helotropha atra*, Grt., thought to be the borer which has injured corn in the northern part of the State for the past two seasons. (3) *Euphoria inda*, Linn., has injured green corn in the ear in several portions of the State. (4) Northern mole cricket (*Gryllotalpa borealis*, Burm.) has injured potatoes on low damp ground. (5) *Saperda cretata* for several years has injured apple trees. (6) Experiments in apiary (pp. 40-42). Experiments in wintering and feeding bees have been kept up for a long time at the college. The Station has not only continued these but has also undertaken experiments under several heads, viz:

Crossing and breeding, with direct reference to the originating of a distinct and improved race; setting various bee plants to ascertain if it will prove profitable to plant solely for honey; and, third, to examine carefully the qualities of various kinds of honey, to determine if possible a test for honey and a means to correct the prevailing but erroneous opinion that honey is frequently and generally adulterated.

A building and grounds were secured, and the old college plant was transferred to

the Station. As the site of the new grounds was where an old brick-kiln had once stood, and where the old brick were still in piles, where deep excavations had been made, and where the hard clay subsoil was now uppermost, the first effort was to grade and fertilize the spot, which has been done. About one hundred and thirty bee trees and shrubs were secured and set out about the apiary grounds. The immediate site of the hives was graded and sodded. The area was planted to Chapman's honey plant, *Echinops sphærocephalus*; alsike clover, *Trifolium hybridum*; a foreign mint; a species of *Melissa*; and Japanese buckwheat. Considering the drought, all the plants have done well. It is against the Chapman's honey plant that it does not bloom the first year after planting, though after that it lives and thrives indefinitely. The melissa blooms early in August and continues to bloom till frost. I believe it is a good honey plant. I need not speak of alsike clover; its excellence as a honey plant and also for hay and pasture have long been demonstrated. The Japanese buckwheat, though it may be no better for honey than common buckwheat, is wonderfully productive, and has a very large kernel. The bees did gather from this buckwheat afternoons as well as early in the day, though not so freely. It is said that bees never gather from common buckwheat after noon. They certainly do from this Japanese. It can also be said that this buckwheat is far more productive than our common buckwheat. We shall continue our experiments with these plants, and shall also add pleurisy root (*Asclepias tuberosa*), a very promising honey plant, and the Rocky Mountain bee plant (*Cleome integrifolia*). This last I have grown for years in small plats, and it seems to me that it promises exceptionally well as a honey plant.

Five years ago experiments in crossing the Carniolan and Syrian races of bees were begun.

Two or three years' previous experience had convinced me that the Syrian bees were exceedingly prolific, and that, with the one exception of amiability, they possessed all the excellent features of the Italian race, in some of which features they excelled even our justly-prized Italians. If our Syrians were a little more amiable, and if their comb honey was as white as that of our German bees, we should have in them a bee superior to any other.

The Carniolan bees, while they are energetic, are amiable beyond any other race. They also give us a very white-comb honey, and barring the fact that they are a little too ready to swarm, they would at once march to the front as the most desirable race of bees known; a position which some of the European bee-masters give them even now. Our bees are very gentle, reminding us of the pure Carniolan, and exceedingly prolific, nearly if not quite equalling the Syrians. Nor do they exhibit any undue tendency to swarm.

Tests for honey.—The impression has got abroad that much of our honey is adulterated. This, whatever may have been the truth years ago, when the price of honey was very high, is not true to-day. Bee-keepers never practiced adulteration. Some years ago dealers did. Now adulteration, owing to the low price of honey, would not pay. From careful investigation I am sure apiarists have never engaged in such dishonest practice. The fact that honey has been very scarce the past year, after the poor honey season of 1887, shows conclusively that adulteration is not now practiced even by dealers, and, as just stated, it will not pay. Yet some of our excellent chemists have reported that adulteration is still practiced. This would be convincing, in spite of the facts just stated, except that some specimens pronounced impure were certainly honey just as it was stored by the bees. This emphasizes the importance of a thorough investigation of the matter of honey tests. Owing to the varying composition of nectar, and the more or less complete digestion of the nectar, it would appear that honey must vary greatly in its composition. This fact, with the known determinations that were incorrect, convince me that it is very important that very careful analyses be made, that we may certainly know the truth, and thus be able to correct the erroneous impressions, which are greatly detrimental to bee-keepers. With this

end in view, I have commenced the collection of honey from various sources and various localities. I have already many samples of known origin. It is the plan to have these tested, and see if it is possible to pronounce with certainty as to the purity of honey. This, then, is the third problem which it is intended to solve.

The present autumn we intend to put a wind-break west of the apiary, and also to set honey-producing shade trees about the grounds. Next year we shall increase our bees till we have seventy-five or one hundred colonies; thus we can investigate any new subject which may arise in connection with apiculture.

Experiments with insecticides (pp. 89-98, Bulletin No. 39).—(1) Codling moths. For the past eight years the value and safety of London purple as a specific against the codling moth has been demonstrated by experiments at this Station. The results of the experiments of 1888 tended to show that it is best to spray apple trees only once unless heavy rains occur soon after the spraying, and that the spraying should be done *never before*, but soon *after* the blossoms fall from the trees. The mixture should be from three-fourths to one pound of London purple to 100 gallons of water. The report contains an illustrated account of spraying apparatus.

(2) Curculio. The above-mentioned solution of London purple was used on plum and cherry trees against the curculio. The conclusion reached was that two or three sprayings were necessary and that a weaker solution would probably be better for the second and third spraying. The solution used blighted the foliage of the cherry trees to a considerable extent. Air-slaked lime and plaster, with carbolic acid (one pint of strong crude acid to 100 pounds of the mineral), were successfully used on plum and cherry trees against the curculio. Plaster is more easily managed than lime. The same mixture was unsuccessfully used against squash-beetles (*Diabrotica vittata*), the black (*Epicauta pennsylvanica*) and ash gray (*Epicauta cinerea*) blister-beetles, and cabbage-maggots (*Anthomyia brassicæ*).

I am more and more convinced that the insects of the genus *Anthomyia*, working on onions, cabbage, and radishes, are one and the same species. There is cumulative evidence that by planting the favorite food plant, probably the radish, among the other plants, especially among onions, the latter may be, if not entirely, at least practically, saved. I believe these plants are relished about in this order by these insects: radishes, cabbages, onions, beans; then soft canes of raspberry, etc.

(4) Ants. Bisulphide of carbon was used against ants with marked success.

Tree-planting (pp. 99-105).—An illustrated article giving an account of the insects which injure maple trees and practical advice regarding tree planting.

REPORT OF BOTANIST, W. J. BEAL, PH. D. (pp. 43-65).—The report deals almost exclusively with the pine barrens. The experimenting was along two lines, viz:

(1) To find one or more grasses or other forage plants that shall be better adapted to the soil and climate than any heretofore in general use in such places.

(2) To test many kinds of forest trees, to learn which are best fitted to plant for timber on the sandy plains.

A list of the grasses and forage plants sown at Grayling is given. About six thousand six hundred trees were planted, belonging to seventy-six species and varieties, thirty-five of which were from Iowa Agricultural College and were raised from stock imported from central Russia. A list of the varieties planted is given. The report also contains an account of field experiments with a variety of crops at Oscoda, Harrison, Baldwin and Walton; a list of plants (with notes) found in northern Michigan; an account of plans for experiments at the college, and an arboretum which now contains about one hundred and fifty species of trees and shrubs; a list of seventy plants found in considerable quantities on the Jack-Pine Plains in the Southern Peninsula of Michigan; a comparison of the flora of eastern and western Michigan in latitude $44^{\circ} 40'$; accounts of the flora of northern Michigan and of the animal life of the pine woods there, and some of the general features of the land and life of the northern part of the State.

REPORT ON DAIRY EXPERIMENTS by a committee of the State Board of Agriculture (pp. 66-68). This contains an account of visits made by the committee to the stations of several States, and recommendations to the Station regarding work which it might do in behalf of the dairy interest both by experimenting and by co-operating with the State Dairymen's Association.

LIST OF BULLETINS PUBLISHED by the College and Station from March, 1885, to November, 1888, with the volume and page of the Reports of the State Board of Agriculture, in which they were permanently bound.

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20	Chemical	November ..	Fertilizer analyses	1886	245
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		1888.			
32	Botanical	February ...	Forestry convention.....	1888	(*)
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40	Horticultural.....	September..	Report	1888	(*)
41	Agricultural.....	October.....	Warming water for cattle.....	1888	(*)
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* See index.

REPORT OF AGRICULTURIST, SAMUEL JOHNSON, M. S. (pp. 70-73—Bulletin No. 34, March, 1889 ; pp. 83-89—Bulletin No. 38, August, 1888; and pp. 139-144—Bulletin No. 41, October, 1888).

Experiment with potatoes (pp. 70, 71).

The soil on which the potatoes were grown was a sandy loam, which had been in wheat plats for the two preceding years. The soil was not manured immediately before the potato crop, but had been enriched with barn-yard manure for several years previous. The land was plowed seven inches deep, harrowed, and marked with furrows four inches deep and three feet apart each way. The potatoes were cut into pieces having from three to four eyes each, or, in case of small potatoes, cut into two pieces, and planted one piece in each hill.

The experiment with different amounts of seed is one which has been repeated on the college farm for three successive years, with about the same results. Last year being a very dry one was a crucial test for the one-eye plant. Many of the pieces dried up, failing to grow entirely, or, in sending up a very feeble growth, were not vigorous enough to stand the drought.

There was a regular gradation in vigor of growth from the one eye up to the whole potato. The one-eye plat produced a larger per cent of small potatoes than usual; in fact there were very few fit for the table. Those from two eyes were a little better in this respect, and the per cent of small potatoes reached the minimum in the three eyes and one-half potato plats. There was a much larger yield in the aggregate from the whole potato. The per cent of small potatoes from this plat was less this year than in previous years.

The tubers were entirely free from rot when harvested, and, with the exception of quite a large per cent of small potatoes, they were of very fine quality throughout. This applies to all the plats and varieties.

Experiments with oats (pp. 72, 73).—Out of eighteen varieties tested only four or five promise any degree of success in this latitude. These are the White Poland, White Victoria, White Russian, Welcome, and Monarch of New Zealand.

Experiments with wheat (pp. 83-87).—The soil of the experimental field is a heavy clay loam, fairly well drained and protected on the east by a belt of timber. After two crops of corn and one of oats it was plowed the middle of August and thoroughly prepared for wheat. The field had received a heavy dressing of barn-yard manure prior to the planting of the second crop of corn. The conditions for all the varieties were as nearly alike as possible.

The yield in bushels per acre was as follows: Clawson, $24\frac{1}{2}$, 27, 28; Champion Amber $20\frac{9}{10}$; Martin's Amber, with salt (150 pounds per acre), 19; without salt, $20\frac{1}{2}$; Rodgers's Amber, $17\frac{1}{4}$; Diehl Mediterranean, 20; Surprise, $15\frac{1}{2}$; Phelps, 17.

Experiments with plaster, ashes and salt, as top-dressing for meadow and pasture lands (pp. 87-89).

Experiment in warming water for dairy cows (pp. 139-144).

A test was made during the winter of 1888 for the purpose of determining how milk and butter products would be affected by warming the water drunk by dairy cows. The details, plans, and results are shown in a series of tables in the report.

The Holstein cow Mae was chosen for the test, which began January 19, 1888.

For the first month the cow was fed bran, ensilage, and corn-stalks. Half the amount of bran and ensilage fed daily was given in the morning and the remainder at night. The stalks were fed at noon.

The second month Mae was fed ensilage, bran, corn meal, and ground oats, mixed; the daily ration was divided into two feeds, while hay was fed at noon.

The first week, and every alternate week during the test, water warmed to 60° F. was given the cow to drink. On the second week and alternating weeks cold water was given her.

Mae was watered at 7 a. m. and 5 p. m. every day during the test.

The temperature was taken each day at 5 a. m.

Recapitulation of results.

With warm water. Milk and butter produced. Total amount of food and water consumed.					With cold water. Pounds of food and water consumed, and milk and butter produced.				
Date.	Food consumed.	Water drunk.	Milk produced.	Butter produced.	Date.	Food consumed.	Water drunk.	Milk produced.	Butter produced.
	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs. oz.</i>		<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs. oz.</i>
January 19-25...	469	550	301	10 5	January 26-Feb- ruary 1.	452	396	288 $\frac{1}{2}$	9 15
February 2-8....	447	641	279	8 14	February 9-15 ..	454	427	272 $\frac{1}{2}$	7 11
February 16-22..	475	398	272	8 2	February 23-29 .	449	442	262	7 12
March 1-7.....	470	618	274 $\frac{1}{2}$	6 15	March 8-14	475	407	258	8 6
Total.....	1,851	2,207	1,126 $\frac{1}{2}$	34 4	Total	1,830	1,672	1,081	33 12
Weekly average.	462 $\frac{3}{4}$	551 $\frac{3}{4}$	281 $\frac{1}{8}$	8 9	Weekly average.	457 $\frac{1}{2}$	418	270 $\frac{1}{4}$	8 7

In the total results there is a balance in favor of warm water, there having been $45\frac{1}{2}$ pounds more of milk produced during the entire period when warm water was given than during the time cold water was drunk.

The balance in favor of warm water in butter product is 10 ounces.

This would indicate a greater relative gain in milk by the use of warm water than in butter.

Mae drank 535 pounds more of warm water than of cold.

If, as is usually conceded, the amount of water drunk increases the flow of milk, the last figures favor warm water.

The results are not as pronounced in favor of warm water as was expected. The difference is so slight as scarcely to pay for warming the water.

The report also contains tables giving the details of the experiment.

REPORT OF METEOROLOGIST, N. B. CONGER (pp. 74-76—Bulletin No. 35, April, 1888).—The report records the organization of the Michigan weather service in 1887.

REPORT OF VETERINARIAN, E. A. A. GRANGE, V. S. (pp. 77, 78—Bulletin No. 36, May, 1888, and pp. 145-152—Bulletin No. 42, November, 1888).

Bulletin No. 36 contains a brief account of proposed experiments in spaying heifers.

Bulletin No. 42 contains a brief account of some inconclusive experiments with oxygen as a remedy for the heaves in horses.

REPORT OF HORTICULTURIST, L. H. BAILEY (pp. 105-139—Bulletin No. 40, September, 1888).—The report contains (1) practical directions regarding the quantity of seed required for given lengths of drill.

Careful records of the quantity of seed used for those vegetables ordinarily sown in drills show that the quantity required is usually much less than that recommended by seedsmen.

- (2) Notes on the hybridization of *Datura stramonium* and *D. inermis*.
- (3) Notes on a number of varieties of radishes.

The salient features which can be used in the classification and characterization of varieties of the radish are the following: Color of root; shape of root; size of root; position of root with reference to the surface of the soil, as to whether it grows mostly below the soil or stands well out of it; shade of top; size of top; date of maturity; quality.

All the radishes which we grew—some two dozen of the spring and summer sorts—possess decided merits in their seasons. It is therefore difficult to name the best varieties. In a general way, it may, perhaps, be said that the following comprise the best sorts: Early White Turnip-rooted, White Olive-shaped, Large White Summer Turnip, Golden Globe, Yellow Summer Turnip, Black Summer Turnip, French Breakfast, Early Round Dark Red, Chartier, Early Long Scarlet, Wood's Early Frame. For market, the gray and black radishes are not often desirable, and the white ones do not ordinarily sell well early in the season, although they are sometimes used for mixing in with red varieties to make the bunches more attractive. As a rule the white sorts are to be recommended for summer use.

- (4) Notes on the influence of certain chemical agents upon germination.
- (5) Tabulated records showing the effect of latitude upon the season of flowering and fruiting, collated from about one hundred and fifty replies to circulars addressed to leading fruit-growers from Michigan to the Gulf States.

MISSISSIPPI.

Mississippi Agricultural Experiment Station.

Department of Mississippi State Agricultural College.

Location, Agricultural College. Director, S. M. Tracy, M. S.

FIRST ANNUAL REPORT, 1888.

REPORT OF DIRECTOR (pp. 5-12).—The report contains the act of the legislature (passed January 31, 1888) establishing the Station under the provisions of the act of Congress of March 2, 1887, and an account of the organization of the Station, its equipment, and the work undertaken, with explanations of the conditions of agriculture in Mississippi which have led to the policy and plans that have been adopted.

In Mississippi, the sudden and abrupt changes in the management of land and labor which were brought about by the war have placed our farmers in such a condition that an almost wholly new system of farming has been inaugurated, and now the production of beef, butter, grain, and other farm products is fast becoming an important part of our agricultural industry, while cotton still remains our most valuable single crop.

Under these conditions the Station has undertaken to work upon some of the problems which are of the greatest immediate practical importance to the farmers of the State. Our soils have become exhausted through long cultivation of cotton, and to restore their fertility is the only means by which we can hope for prosperity. To ascertain how this can be done most economically is the primary object of this Station.

The director of the Station and the professor of agriculture in the Agricultural College, who is also farm superintendent, agree upon lines of work which shall, as far as possible, harmonize the work of the Station and the College, so that the farm work of the College is, to a great extent, a duplication on a large scale of the most successful work done by the Station. This arrangement brings the field work of both in close relations, strengthening and emphasizing both.

A similar plan is followed in horticultural work.

As no funds for expenses were received until March 15, when the season was too far advanced for much planting, no large amount of experiment work could be completed before the publication of this report, but the time of the working force has been very fully occupied in building, the selection and arrangement of equipment, clearing, fencing and draining land, the planting of fruit trees, grasses, etc., and the necessary preliminary work which must always precede any carefully conducted experiments.

FERTILIZER CONTROL (pp. 14-26).—Here are given explanations regarding fertilizers; full text of the laws of the State for the control of commercial fertilizers; directions for taking samples of fertilizing materials for analysis, forms for labels, and certificates to accompany samples for analysis; explanations of fertilizer analyses and valuations of fertilizers; and tables showing the results of the analyses made at the Station during 1887 and 1888.

FIELD EXPERIMENTS WITH FERTILIZERS (pp. 27-30). (1) *Corn* (pp. 27-29).—The report contains plans, details, and tabulated results of an experiment to determine whether any of the fertilizers used (commercial fertilizers of various kinds and cotton-seed meal) will be profitable for

continued use on representative soils with a four-year crop rotation, consisting of cotton, corn, and the remaining two years in clover. This being the second year of the rotation, the field was planted in corn. The experiment is to be repeated in successive seasons. The results thus far obtained are, of course, inconclusive.

(2) *Cotton* (pp. 29, 30).

Two fields were plowed on April 12, and planted in cotton on April 18, the rows being $3\frac{1}{2}$ feet apart. Owing to the unusual drought many of the seed did not germinate until May. Lot B was on high land and lot A in bottom lands, which were overflowed during the severe storms in August. On lot B, plats 3, 4, and 5, stable manure was spread at the rate of $2\frac{1}{2}$ tons per acre before plowing. Other fertilizers were applied on the rows, as indicated by the table. Both lots were hoed twice, barred off twice, and cultivated with a double-shovel plow four times. The results were as follows:

Plats.	Fertilizer.	Yield per acre.	Gain.	Cost of gain per 100 pounds.
		<i>Pounds.</i>	<i>Pounds.</i>	
B 1	250 pounds bone meal, May 30	885	.....	.....
2	200 pounds cotton-seed meal, May 30	1,320	.....	.....
3	400 pounds acid phosphate, July 1*	1,880	.....	.....
4	20,000 pounds stable manure, April 1	2,160	.....	.....
5	400 pounds bone meal, July 1*	2,280	.....	.....
A 1	400 pounds cotton-seed-hull ashes, May 30	2,340	900	\$0.55
2 .....	.....	1,440	.....	.....
3	400 pounds acid phosphate, May 30	1,860	375	1.33
4 .....	.....	1,530	.....	.....
5	400 pounds bone meal, May 30	1,650	135	4.44
6 .....	.....	1,500	.....	.....
7	400 pounds cotton-seed-meal, May 30	2,340	645	.62
8 .....	.....	1,890	.....	.....

* Two and one-half tons stable manure applied April 1.

In lot A the cost of increase per 100 pounds of seed cotton varies from 55 cents with cotton-seed-hull ashes to \$4.50 with bone meal. Cotton-seed meal gave nearly as good results as did the ashes.

FORAGE CROPS (pp. 30-32).—Brief accounts of experiments with forage crops are given under the following heads:

(1) *To test the comparative results of drilling and broadcasting corn for ensilage.*—The results were in favor of drilling, the yield being 2,925 pounds per acre greater by this method than by broadcasting, and the net financial advantage of the former method being \$3.35 per acre.

(2) *To test the advantage of tile-drained land as compared with un-drained land.*—The difference in favor of the former was 3,552 pounds of ensilage corn, or \$6.10 per acre.

(3) *Experiments with Japan clover (*Lespedeza striata*) on a worn-out cotton field.*—The best result was obtained from the plat fertilized with 100 pounds of cotton-seed meal, 100 pounds acid phosphate, and 30 pounds muriate of potash, which produced at the rate of 5,180 pounds per acre. The plats which were either unfertilized or fertilized with cotton-seed hull ashes or bone meal produced scarcely anything.

GRASS ANALYSES (p. 33).—The following table gives the results of analyses of Southern grasses made at the Station:

Name.	Station No.	Moisture.	Crude fiber.	Crude protein.	Fat.	Nitrogen free extract.	Ash.
<i>Andropogon dissitiflorus</i> (Broom sedge).....	120	9.32	36.06	5.12	.74	44.76	4.00
<i>Sorghum vulgare</i> (Chicken corn, before heading)	122	13.63	32.82	7.50	.96	34.80	10.29
<i>Sorghum vulgare</i> (Chicken corn, just headed)	133	9.43	34.62	6.25	2.17	42.80	4.73
<i>Leersia oryzoides</i> (Cut grass)	119	9.42	28.60	6.56	1.95	44.39	9.08
<i>Muhlenbergia diffusa</i> (Nimble will) ..	121	13.27	29.88	6.25	2.33	41.72	6.45
<i>Panicum autumnale</i> (Fall panic) ...	118	15.07	28.65	12.19	2.02	38.80	3.27
<i>Panicum capillare</i> (Hair grass)	123	12.17	34.45	6.88	2.14	38.21	6.15
<i>Panicum sanguinale</i> (Crab grass) ..	124	6.81	28.20	5.88	2.23	43.52	8.30
<i>Panicum filiforme</i> (Crab grass)	129	12.43	30.12	7.50	1.60	42.25	6.10
<i>Panicum anceps</i> (Double panic) ..	131	11.21	32.52	7.50	1.05	40.82	6.90
<i>Paspalum floridanum</i> (Barn-yard grass)	127	8.56	29.75	6.25	.96	50.23	4.25
<i>Sorghum halepense</i> (Johnson grass) ..	125	7.57	29.82	8.70	2.38	44.32	7.21
<i>Sorghum halepense</i> (Johnson grass, over-ripe)	132	9.80	35.72	4.18	1.36	44.34	4.60
<i>Sporobolus asperifolius</i> (Dropseed) ..	130	9.97	35.87	5.62	1.17	42.57	4.80
<i>Triodia seslerioides</i> (Purple top)	126	12.05	35.30	5.94	1.44	25.70	9.57

* ANALYSES OF FEEDING STUFFS (pp. 33-40).—The report reprints the table of analyses of American feeding stuffs compiled by Dr. Jenkins, of the Connecticut Station, and also gives tables of analyses of feeding stuffs and their digestibility, and tables of feeding standards obtained chiefly from the German stations and published in the report of 1885 of the Connecticut Station.

EXPERIMENTS TO TEST THE EFFECT PRODUCED BY SALTING COWS UPON THE PRODUCTION OF MILK (p. 42).—This experiment was performed on three cows. The result strongly favored the use of salt.

EXPERIMENTS SHOWING THE ADVANTAGE OF THOROUGH MILKING (p. 42-43).

Every one who has his milking done by hired hands knows the extreme difficulty in finding a milker who will do his work thoroughly. The milking is very likely to be done before breakfast or after dark when the hands are in a hurry, and take but little pains to secure the last of the strippings—the best part of the milk. In order to ascertain the probable extent of the loss from careless work in milking, five cows were given to one of our workmen, A., who was supposed to be a good milker, and who milked them for two weeks, weighing each milking from each cow. Nothing was said to him concerning the object of the trial. At the end of the time, the same cows, with the same feed and care, were given to another workman, B., who was told the object of the work. The results are shown below:

Cow.	Milker A.	Milker B.	Gain.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1	128.5	154.	25.5
2	138.	206.5	68.6
3	199.	275.5	76.5
4	161.5	172.5	11.
5	160.5	223.5	63.

Showing a total gain of 244.5 pounds in favor of good work with five cows for two weeks; an average of two and one-half pounds per day for each cow.

EXPERIMENTS IN FEEDING CALVES (p. 43).—The result shows that skimmed milk was much the cheapest food, as compared with whole milk, and a mixture 10 pounds of skimmed milk and one pint of Blatchford's food.

SUGAR AND MOLASSES (pp. 44–47).—The report gives a brief description of the manipulation of cane juice in the manufacture of sirup from cane grown on a farm adjoining the Station, as practiced by the station chemist, and a diagram of a simple and inexpensive arrangement for sulphuring the juice.

HORTICULTURAL WORK (pp. 47–49).—(1) Account of the use of fertilizers on apple, pear, and peach trees. (2) List of varieties of fruits planted. (3) Account of the planting of one hundred and thirty-one species of forest trees.

Sweet potatoes (p. 49).—To test the comparative merits of different varieties of sweet potatoes, eleven varieties were planted on low, well-drained sandy land. The planting was done on June 20, all the plots being cultivated and otherwise treated alike. On November 10 the crop was harvested, with the following results:

Variety.	Yield per acre (small).	Yield per acre (salable).	Total yield per acre.
	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>
Boone red	40	61	101
Spanish poplar.....	94	43	137
Florida yam.....	61	293	354
Georgia yam	38	185	223
Red-skinned yellow yam	39	90	129
San Domingo	124	211	335
Boone red and white.....	54	112	166
Yellow Nansemond.....	39	154	191
Yellow yam.....	56	99	155
Southern Queen.....	42	147	189
Pumpkin yam.....	41	225	266
Average yield.....	57	147	204

For a fertilizer test, nine plots were planted with Yellow yam, all being on a rather heavy clay soil. Results were as follows:

No. plot.	Fertilizer.	Yield.
		<i>Bushels.</i>
1	100 pounds cotton-seed meal.....	167
2	100 pounds acid phosphate	78
3	75 pounds cotton-seed-hull ashes	146
4	No fertilizer.....	87
5	50 pounds cotton-seed meal and 50 pounds muriate of potash.....	166
6	50 pounds cotton seed meal and 50 pounds soluble acid phosphate.....	142
7	30 pounds acid phosphate and 30 pounds plaster.....	96
8	50 pounds acid phosphate and 50 pounds plaster.....	82
9	40 pounds muriate potash and 30 pounds nitrate of soda	128
	Average.....	126

METEOROLOGICAL WORK (pp. 50–62).—The report contains tabulated observations for each month of 1888.

MISSOURI.

Missouri Agricultural Experiment Station.

Department of Missouri Agricultural College..

Location, Columbia. Director, J. W. Sanborn, B. S.

FIRST ANNUAL REPORT.

REPORT OF STATION SECRETARY, S. C. YEAMAN (pp. 1, 2). The report contains an account of the organization and equipment of the Station and the following list of bulletins:

(1) Announcement of organization and proposed first experiment. "A study of the life history of the corn plant, and of the physical and chemical conditions of climate, soil, and atmosphere that determine its profitable growth."

(2) Grasses for pastures and meadows; by J. W. Sanborn, B. S.

(3) Generalities and experiments in spaying cattle; by Paul Paquin, M. D., M. V.

(4) A test of tillage implements; by J. W. Sanborn, B. S.

NEBRASKA.

Agricultural Experiment Station of Nebraska.

Department of University of Nebraska.

Location, Lincoln. Director, Charles E. Bessey, Ph. D.

SECOND ANNUAL REPORT.

REPORT OF DIRECTOR (pp. 5-22).

The regents of the University have set apart certain rooms and tracts of land for the use of the Station. In some instances this use is exclusive, while in others there is a joint use by the Station and the department of instruction. The Experiment Station has thus no single room or building for its location, but its work goes on in many rooms in several buildings, as well as upon different tracts of land.

Upon the completion of the new Industrial College building, "Nebraska Hall," now nearly accomplished, the departments of geology, entomology, and botany will be permanently quartered in it, in rooms especially planned for them.

It is the plan of the management of the Station to select from the many lines of investigation suggested by the law of Congress a few of those which are most important for the people of Nebraska, leaving for the future many questions which are not of such immediate importance. Accordingly the funds at command have been used in varying amounts for work in half a dozen lines, viz: field agriculture, chemical problems, meteorology, animal diseases, agricultural geology, and injurious insects.

For the present the Station will give a large share of its attention to the study of diseases of the domestic animals. In Nebraska the annual loss from one disease alone, swine plague, probably exceeds a million dollars. Another important line of work in this State is the investigations of grasses and forage plants, with a view to the introduction of new varieties. These investigations will include not only species of

grasses and forage plants from the older States and from Europe, but also wild plants collected on the uncultivated plains of the West.

The experimental work undertaken includes a series of observations upon soil temperatures, the varying rain-fall in different fields, the amount of soil evaporation, subsoil irrigation, soil water, native and introduced grasses, the clovers, other forage plants, cereals, and garden crops.

The results of some of this work have been published in Bulletin No. 6.

In Chemistry the plan of work—

contemplates a mechanical and chemical analysis of the characteristic soils and an analysis of the "ground water" of the regions from which the soils are taken, as well as analyses of the waters of deep wells, artesian wells, springs, lakes, and rivers of Nebraska.

Samples of the "bottom" and "upland" soils, including, whenever practicable, both surface and subsoils, in the regions drained by the principal streams in each of the geological districts of the State will be first selected for investigation.

In Meteorology the work has been a continuation and extension of that already undertaken by the University. Observations are made three times daily on temperature, humidity, atmospheric pressure, velocity and direction of wind, and cloudiness.

Daily observations are made on maximum and minimum temperature, barometric change, rain-fall, total distance traveled by the wind; and the mean temperature, mean relative humidity, mean barometer pressure, and average direction of wind are estimated.

Veterinary Science.—The work of the past year includes the following:

- (1) A continuation of the investigations upon swine plague.
- (2) Investigations as to the nature of Texas fever.
- (3) Investigation upon a contagious eye disease in cattle.
- (4) Investigations upon a contagious disease of the external sexual organs in cattle.
- (5) Studies upon the so-called rabies in cattle, a disease causing much loss in the State.
- (6) Studies on a new disease in cattle which has been mistaken for anthrax, and causes a great deal of loss.
- (7) Studies of actinomycosis in cattle, a disease which is extending in all parts of the State.

This department of the Station occupies three rooms in the main University building for laboratory, culture room, and office. On the University campus it has an animal house for small animals (rabbits and guinea-pigs.) An experimental building has been constructed upon the college farm, designed for careful experiments upon animals. This is fitted with iron cages upon a concrete floor, and is carefully heated and ventilated. Its dimensions are 60 feet by 26.

The Station has a collection of forty rabbits and twenty guinea-pigs for use in inoculations, with other small animals, as mice, squirrels, etc., as well as a supply of larger animals, which are available for experimental purposes.

The apparatus in the laboratory and culture room is extensive and of the most approved construction, and includes glassware, chemicals, sterilizing apparatus, etc., and several Leitz microscopes with objectives especially made for bacteriological investigations.

The report contains the ground plan of the buildings required for the use of this department.

In Geology "two lines of investigations have been undertaken, viz: (1) The study of soils in relation to the subjacent rocks, and (2) the extent to which irrigation may be advantageously used in Nebraska."

In Entomology 12,000 to 15,000 specimens of miscellaneous insects have been collected to form a nucleus of a reference collection of the insects of Nebraska.

In Botany the work planned includes (1) the study of native grasses of the State, and (2) the study and observation of the injurious fungi of the State.

Report of the visiting committee (pp. 16-19).—This committee is appointed by the State Agricultural Society at request of the Board of Control of the Station, and consists of two members from the State Agricultural Society and one member from the State Horticultural Society, who are to visit the Station at least once each year, and submit a report to the Board of Regents of the University and to the governor. The report for 1888 cordially commends the work of the Station.

Publications of the Station.—The publications of the Station are the following:

Bulletin No. 1. Irrigation in Nebraska, by Lewis E. Hicks (32 pp., 8vo.). Distributed January 20, 1888. The edition of 1,200 copies is exhausted.

Bulletin No. 2. Twenty-two Common Insects of Nebraska, by Conway McMillan, (102 pp. 8vo.). Distributed February 6, 1888. Edition of 1,200 copies; some yet remaining.

First Annual Report (30 pp., 8vo.). Distributed February 11, 1888. Edition of 500 copies; some yet remaining.

Bulletin No. 3. Southern Cattle Plague and Yellow Fever, from the Etiological and Prophylactic Stand-points, by Frank S. Billings (142 pp., 8vo.). Distributed March 13, 1888. The edition of 1,200 copies is exhausted.

Bulletin No. 4. Swine Plague, its Causes, Nature, and Prevention, by Frank S. Billings (414 pp., 8vo.). Distributed June 30, 1888. The edition of 1,500 copies is entirely exhausted, and a second of 600 is nearly so.

Bulletin No. 5. Some Injurious Insects of the year 1888, by Lawrence Bruner. (In the press.)

Bulletin No. 6.—

Article IV. Report of Progress, including a history of the fields and description of the animals available for experimentation, by Henry H. Wing.

Article V. Field Experiments and Observations for the year 1888, by Jared G. Smith.

Article VI. Meteorological Record for the year 1888, by De Witt B. Brace. (In the press.)

The act of the legislature assenting to the act of Congress of March, 2, 1887, is given in full on pages 41 and 42.

The report contains (page 6) illustrations of the exterior of the two principal buildings used by the Station.

NEVADA.

Nevada State Agricultural Station.

Department of Nevada State University.

Location, Reno. Director, LeRoy D. Brown, Ph. D.

FIRST ANNUAL REPORT, 1888.

REPORT OF DIRECTOR (pp. 3-6).—The report contains an account of the equipment of the Station.

REPORT OF LIBRARIAN, H. K. CLAPP, A. M. (pp. 10-12).

REPORT OF BOTANIST, CHEMIST AND METEOROLOGIST, W. MCN. MILLER, B. SC. (pp. 13-16).—The report consists for the most part of an account of an equipment of the Station in this department.

A full text of an act of the legislature, approved February 8, 1889, organizing the Board of Control of the Station, is given on page 17.

NEW JERSEY.

New Jersey State and Agricultural College Experiment Stations.

Location, New Brunswick.

Director, George H. Cook, LL. D.

NINTH ANNUAL REPORT OF STATE STATION AND FIRST ANNUAL REPORT OF COLLEGE STATION.

REPORT OF DIRECTOR (pp. 17-23).—The ninth annual report of the New Jersey Agricultural Experiment Station, which is herewith made, is joined with that of the New Jersey Agricultural College Experiment Station, the first report of which is also here presented. Both Stations are established for the benefit of agriculture and its improvement by scientific experiments and investigations, conducted by specialists, who are provided with the necessary buildings and equipments, occupying common ground, and with fields wide enough for the occupancy of both; their managers at the outset voted that the work of one should supplement that of the other, and during the past year it has been carried on in accordance with the spirit of the above vote.

The work of the New Jersey Experiment Station continues to be applied to the analysis of fertilizers, feeds and fodders, and the questions connected with the production and quality of milk. Various field experiments have also been continued, in particular experiments connected with the production of sorghum and sugar; and in general, it continues work upon those subjects which have been considered to almost come within the police jurisdiction of the State. Its officers are chemists, of whom four or five are employed, and its questions mostly chemical. The Agricultural College Experiment Station takes up the work where it is necessarily left by the State Station, and continues it further, and devotes more attention to the investigation of the principles of science which underlie the various branches of agricultural and horticultural practice. It has a botanist and horticulturist, whose experiments are with the quality of seeds, the growth of staple crops, the diseases of plants, and the conditions requisite for healthy growth and development. It employs an entomologist, whose attention is given to studying the habits of insects both useful and injurious, and to experiments for benefiting the one and destroying the other. It engages the services of an accomplished biologist, who has thus far given his attention mainly to studying our resources of fish and shell-fish, and in particular to the oyster industry of the State, and the field for its productive increase and its extension. It has a chemical geologist, whose attention is given to the study of soils, marls, and lime-

stones, and the changes to be wrought in soils by proper tillage. Other specialists will be called in as the demands of the farmers may require.

The organizations of the two Stations are given in this report, and their united forces can do much more for the improvement of our agriculture than the two could if working in different and separate places.

The State Station has never had any laboratory or other building of its own, but has occupied rooms in the buildings of Rutgers College. The enlargement of the Agricultural College, by the addition of an Agricultural Experiment Station, and the increased work of the State Station, made it necessary to provide additional buildings. The legislature of 1888 appropriated \$30,000 for the erection of a laboratory for the Station. A liberal friend gave the land on which to build it; the United States appropriation to the Agricultural College Experiment Station authorized the expenditure of \$3,000 in providing buildings; and money saved from the annual appropriation for the State Station has further increased the building fund; so that in all it will amount to near \$40,000. The new laboratory is inclosed, and it is expected that it will be finished by the opening of the spring of 1889. It is a building of stone and pressed brick, 100 feet long and 50 feet wide, with two full stories, a high and well-lighted basement, and an attic with capacity equal to either of the other stories. This building will provide ample accommodations for the chemists, chemical geologists, botanists, biologists, entomologists, and other specialists who may be engaged in experiment work, and will also have rooms for laboratories, lectures, farmers' meetings, etc.

In the prosecution of the station work, analyses have been made of 170 complete fertilizers, 78 incomplete fertilizers, 33 miscellaneous specimens; also 9 analyses of feeds and fodders have been made. Field experiments have been made upon wheat, peach trees, millet, alfalfa, and sorghum, and upon the effect of different simple and mixed fertilizers upon crops. Experiments have also been made for destroying noxious insects. Important investigations have been begun upon the sources for the supply of fish and shell-fish from our own waters and the means for their improvement. Investigations have also been commenced for the description and classification of the different soils of the State and the agencies which may be applied to develop their best natural productiveness. The value of our waters for the production of food-fish and shell-fish has never been appreciated. Our best oyster lands will produce more than ten times as much value as our average farms do. There are more than 150,000 acres of them. They are not all improved, though they are capable of as much improvement as any farm land. We have 13,000 acres in lakes, ponds, and running streams. In all these fish can be cultivated, and the value to be produced from them is quite as large as that from an equal area of good upland. This value has not been realized up to the present time, but those best informed upon the subject say that it can and ought to be done. And our biologist enters upon the subject with confidence that he can contribute something to this end.

The study of soils and their properties and composition has not in recent times received the attention it deserves. It is easier to apply fertilizers than it is to get out the natural richness of the soil. But it is by no means certain that it is more profitable. Thorough and good tillage may develop in a soil sources of fertility which under ordinary treatment are totally unavailable. There are in our State soils which have within six inches of their surface enough potash and phosphoric acid to supply the crops for a hundred years to come, and a good stock of nitrogen and the other elements of fertility. They need more complete exposure to the benignant influences of air, moisture, and warmth. There are still in New Jersey 2,069,819 acres of upland unimproved, of which more than half are now capable of profitable cultivation. Some of them will need fertilization, but they will respond to thorough tillage, and give full return for all the work bestowed upon them.

Arrangements are also made for a careful and thorough trial of the leading breeds of dairy cows, so as to help determine the cost of their keep and the value of their

product. The trial will need to be conducted both at the cow-stables and in the laboratory, and to be continued for at least three years.

The results of the investigations upon the growth of sorghum and the manufacture of sugar demonstrate that good crops of cane can be grown upon the soils of southern New Jersey by the aid of rather inexpensive fertilizers, and that by the diffusion process nine-tenths of the sugar can be extracted in a solution but very little weaker than the natural juice. The present experience is that the sorghum-sugar manufacture can be carried on to good advantage, and with good efficiency of labor and capital, in sugar-houses working not more than 40 tons of cane daily, and that with a season of seventy days, which may be reasonably expected, 2,800 tons of cane may be worked in the mill, and a product of 232,000 pounds of sugar and 30,800 gallons of sirup obtained. This amount can be grown upon 250 acres of ground, and may be produced upon a farm of 1,250 acres without materially diminishing the other crops of the farm.

This is the present condition of the manufacture where the cane yields only 8 per cent of sugar and the season of manufacture is limited to seventy days. But there are now single canes to be found which yield 12 and even 14 per cent of sugar, and by careful selection and cultivation it may reasonably be expected that the whole crop may be enriched up to this standard, as it has been in the case of the sugar beet. There is no staple crop now cultivated in our country which gives promise of such good returns or of so great improvement as this; neither is there one in which a mixed industry of agriculture and manufactures can be so generally distributed.

The benefits coming to our farmers from the work of the Experiment Station continue to be satisfactory. Seven bulletins have been sent out since the issue of the last annual report, and the mailing list is increased to nearly 11,000. The early and wide distribution of the results of the station work quickens attention and brings useful information to the farmer. The sale of fertilizers is to a large extent regulated by the analyses made at the station laboratory. The inquiries made by farmers are of more than daily occurrence, and they indicate a marked and large increase of knowledge of the first principles of agriculture. The correspondence started by these inquiries is constituting an important part of the station work, and the inquiries made and answers given, when recorded, will become an important part of our reports.

There has been no very marked change in the amount of chemical fertilizers used in the State during the past year. From the nearest estimates the Station can make, about 33,600 tons have been sold to our farmers, with a value of \$1,125,800. The analyses show that the respectable manufacturers are becoming more careful to make their goods conform closely to their published guarantees of composition. But few brands of spurious or of greatly-overrated fertilizers have been sold to our farmers, and these must have been in very small quantities.

Three inferior brands of fertilizers are mentioned by name and number of station analysis. One is "very far below the selling price. It does not, in its printed analysis, promise much commercial value. There is no occasion for a farmer to complain if he buys this. An intelligent examination of the analysis printed on the bags or packages will show how little of valuable fertilizing material is in them."

Another "comes in its valuation far below the price at which it is sold, and it also comes below the manufacturer's guarantee as printed in the analysis."

The third represents brands occasionally found which are not accompanied by any analysis.

Its selling price is almost three times its proper price. For cases like this, too, the buyer has only himself to blame. No high-priced fertilizer should be bought unless accompanied by a guaranteed analysis.

In examining the analysis attention need only be given to the lower quantity of each ingredient, as this is all the manufacturer guarantees. When these analyses are plainly given, buyers have only themselves to blame if they pay more for their fertilizers than they are worth in market.

The prices of fertilizers have been fully maintained throughout the year, and those of some kinds of stock have increased, so that manufacturers are asking to have the station valuation for the coming year increased a little.

REPORT OF CHEMISTS, A. T. NEALE, PH. D.; EDWARD B. VOORHEES, A. M.; HENRY R. BALDWIN, JR.; AND LOUIS A. VOORHEES, A. B. (pp. 24-162).

Fertilizer statistics (pp. 25-30).

The quantity and value of the fertilizers used in New Jersey during the year 1888.

	Tons reported as sold in New Jersey.	Retail price per ton.	Total value.
Complete manures	25,413	\$34.83	\$885,135
Dissolved bones, etc.	1,016	31.90	32,410
Ground bones	2,036	33.76	68,735
Kainit.	604	12.83	7,749
Muriate of potash	449	42.33	19,006
Ammonite, dried blood, etc.	1,703	36.66	62,432
Ammonium sulphate	53	69.70	3,694
Sodium nitrate	157	52.00	8,164
Bone-black superphosphate	457	24.80	11,334
South Carolina rock phosphate	1,745	15.60	27,222
Total number of tons and value	33,633	.....	\$1,125,881

It is admitted that these statistics are incomplete, as they represent 44 manufacturers only of the 72 whose brands have this year been sampled in this State and analyzed by this Station.

The following tables show the comparative tonnage of fertilizers and the average retail prices for several years:

Tonnage of fertilizers used in New Jersey.

Fertilizers.	1882.	1884.	1885.	1886.	1887.	1888.
	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>
Complete manure	15,941	21,894	22,424	24,498	22,500	25,413
Ammoniated superphosphate without potash (dissolved bone, etc)	1,370	1,541	1,603	1,343	1,898	1,016
Ground bones	2,509	3,172	2,237	2,338	2,465	2,036
Kainit	683	991	584	1,106	1,220	604
Muriate of potash	144	291	331	255	314	449
Ammonite	719	783	250	*698	.....	*1,703
Ammonium sulphate	76	54	55	21	95	53
Sodium nitrate	26	40	17	24	93	157
Blood	244	1,581	263	.....	411	.....
Fish	228	228	.....	.....	184	.....
Hair	248	574	434	723	363	.....
Poudrette	3,450	10,200	6,000	5,000	.....	.....
Superphosphates, 30 to 40 per cent	562	.....	.....	.....	.....	.....
Superphosphates, 11 to 18 per cent	3,963	5,315	.....	.....	.....	.....
Bone-black superphosphate .....	.....	.....	2,488	594	370	457
South Carolina Rock .....	.....	.....	1,124	2,078	1,303	1,745
Total	30,163	46,664	37,810	38,678	31,216	33,633

*The total number of tons, in 1886, and 1888, under ammonite, includes both blood and fish, returns having been made in many cases without discrimination.

The average retail prices for 1882, 1884, 1885, 1886, 1887, and 1888.

	1882.	1884.	1885.	1886.	1887.	1888.
Complete manure.....	\$41.00	\$38.00	\$35.73	\$36.68	\$34.80	\$34.83
Ammoniated superphosphate without potash (dis- solved bone, etc.).....	32.00	31.00	31.62	29.25	32.63	31.90
Ground bone.....	37.00	36.00	31.25	34.35	35.39	33.76
Kainit.....	12.00	10.00	11.75	10.60	10.25	12.83
Muriate of potash.....	41.00	38.00	42.15	42.00	39.54	42.33
Ammonite.....	56.00	43.00	43.00	40.40	.....	36.66
Ammonium sulphate.....	99.00	70.50	68.50	70.00	68.20	69.70
Sodium nitrate.....	76.00	54.00	52.25	58.72	51.61	52.00
Blood.....	56.00	43.50	38.67	.....	35.33	.....
Fish.....	45.00	31.50	34.66	.....	35.17	.....
Hair.....	10.00	11.00	10.00	10.00	.....	.....
Poudrette.....	10.00	10.00	10.00	10.00	.....	.....
Superphosphates with 30 to 40 per cent phosphoric acid.....	75.00	.....	.....	.....	.....	.....
Superphosphates with 11 to 18 per cent phosphoric acid.....	28.50	24.50	.....	.....	.....	.....
Superphosphates made from bone-black.....	34.00	26.00	29.86	25.85	26.95	24.80
Superphosphates made from South Carolina rock...	26.60	20.00	20.31	17.75	17.73	15.60

† The prices for blood, ammonite, and fish have been averaged for the years 1886 and 1888, for reason mentioned above.

The total tonnage for 1888 is 8 per cent greater than that for 1887, but the sales of complete fertilizers have increased nearly 13 per cent. Eighty per cent (\$885,000) of the total expenditure for fertilizers was paid for complete manures. The analyses made at the Station show that the decline in the price of complete fertilizers has not been accompanied by a corresponding decrease in the absolute amounts of plant-food delivered to consumers.

The total cash value of the reported sales of commercial fertilizers in this State during 1888, as compared with that of previous years, is as follows:

Total value of fertilizers reported for—

1882	\$1,070,113	1886	\$1,181,266
1884	1,369,004	1887	1,022,434
1885	1,116,670	1888	1,125,881

Commercial relations of fertilizers (pp. 30-81).

(1) *Market prices of fertilizers (pp. 30-36).*—Efforts were made to secure—

The average wholesale prices of nitrogen, phosphoric acid, and potash.

The average retail prices of nitrogen, phosphoric acid, and potash.

The advance in prices between the wholesale and retail markets.

The wholesale prices are obtained from the Oil, Paint, and Drug Reporter and tabulated for the entire year, the results expressed in the form adopted by the experiment stations of this country.

The retail prices were secured by the chemists of this Station, who visited all of the principal factories in which fertilizers are mixed, sampled all crude products found, and learned from the owners the rates charged per ton each of said products before they were mixed to form complete manures.

Table showing retail prices of nitrogen, phosphoric acid and potash in various products.

Products.	1884.	1885.	1886.	1887.	1888.
Nitrogen from—	<i>Cts.</i>	<i>Cts.</i>	<i>Cts.</i>	<i>Cts.</i>	<i>Cts.</i>
Nitrate of soda	16.9	16.1	18.2	16.0	16.3
Sulphate of ammonia	17.1	16.7	18.1	16.5	17.0
Dried blood	18.3	15.5	20.0	16.4	14.4
Dried fish .....	.....	14.8	*16.6	15.2	15.3
Ammonite and tankage	15.8	16.1	.....	†15.2	†15.4
Soluble phosphoric acid from—					
Bone-black	7.3	7.8	7.8	8.2	7.5
S. C. rock	8.6	8.6	7.4	7.5	6.2
Reverted phosphoric acid from—					
Bone-black	6.7	6.9	7.8	8.2	7.5
S. C. rock	7.8	7.6	7.4	7.5	6.2
Insoluble phosphoric acid from—					
Bone-black	2.9	1.7	1.9	2.0	1.9
S. C. rock	1.9	1.9	1.9	1.9	1.5
Potash from—					
High-grade sulphate .....	.....	6.7	5.8	5.7	4.7
Double sulphate of potash and magnesia	7.2	6.8	6.5	6.2	6.1
Kainit	4.5	4.5	4.2	4.0	5.1
Muriate	4.2	4.1	4.0	4.1	4.0

*This average also represents the retail cost of nitrogen in ammonite and castor pomace.

†Does not include tankage.

These averages are the *manufacturers' retail cash prices for the nitrogen, phosphoric acid, and potash in the crude stock from which complete fertilizers are made.*

COMPARISON BETWEEN THE AVERAGE WHOLESALE AND RETAIL PRICES OF NITROGEN, PHOSPHORIC ACID, AND POTASH.

The conclusions reached in regard to the wholesale and retail prices are here tabulated. They represent the manufacturers' *wholesale* and *retail* prices for plant food in its best forms. The percentage by which the retail prices exceed the wholesale have been taken as the basis of the comparison:

	Manufacturers' averages.				Average percentages by which the retail prices exceed the wholesale.		
	Wholesale prices for 1887.	Retail prices for 1887.	Wholesale prices for 1888.	Retail prices for 1888.	1886.	1887.	1888.
Nitrogen from—	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>			
Nitrate of soda	13.0	16.0	13.2	16.3	27.3	23.1	22.5
Sulphate of ammonia	14.6	16.5	15.8	17.0	19.9	13.0	7.6
Dried blood	13.0	16.4	13.6	14.4	40.8	26.2	6.0
Dried fish .....	.....	15.2	.....	15.3	.....	.....	.....
Ammonite	13.5	15.2	13.8	15.4	13.7	12.6	11.6
Soluble phosphoric acid from—							
Bone-black .....	.....	8.2	.....	7.5	.....	.....	.....
S. C. rock	5.64	7.5	4.7	6.2	35.0	33.0	33.3
Reverted phosphoric acid from—							
Bone-black .....	.....	8.2	.....	7.5	.....	.....	.....
S. C. rock	5.64	7.5	4.7	6.2	35.0	33.0	33.3
Insoluble phosphoric acid from—							
Bone-black .....	.....	2.0	.....	1.9	.....	.....	.....
S. C. rock	1.41	1.9	1.2	1.5	38.7	35.0	33.3
Potash from—							
High-grade sulphate .....	.....	5.7	.....	4.7	.....	.....	.....
Doublesulphates of potash and magnesia	4.4	6.2	4.5	6.1	51.2	40.8	35.5
Kainit	3.1	4.0	3.8	5.1	44.8	29.0	34.2
Muriate	3.5	4.1	3.6	4.0	14.3	17.1	11.1

(2) *Sources and quality of the nitrogen, phosphoric acid, and potash found in complete fertilizers* (pp. 36-45).—From the tables given in the report the following statement of the average cost per pound of the above-mentioned elements of plant food has been collated:

No. of analyses.	Source.	Cost per pound	Remarks.
		<i>Cents.</i>	
	Nitrogen from—		
8.....	Nitrate of soda	16.25	} Soluble in water.
9.....	Sulphate of ammonia.....	17	
2.....	Dried blood.....	14.4	
6.....	Dried fish	15.3	} Insoluble in water.
5.....	Ammonite and castor pomace	14.6	
5, finer than $\frac{1}{50}$ inch.	Tankage and Swift-sure guano.....	13.6	
5, finer than $\frac{1}{25}$ inch.	do	10.7	
5, finer than $\frac{1}{12}$ inch.	do	8.6	
5, finer than $\frac{1}{8}$ inch.	do	7	
	Phosphoric acid from—		
10.....	Bone-black	{ 7.48	Soluble in water.
		{ 7.48	Soluble in ammonium citrate.
		{ 1.87	Insoluble.
7.....	South Carolina rock.....	{ 6.16	Soluble in water.
		{ 6.16	Soluble in ammonium citrate.
		{ 1.54	Insoluble.
	Potash from—		
12.....	Muriate of potash.....	4	
6.....	Kainit	5.1	
5.....	Double sulphates of potash and mag- nesia.	6.1	
2.....	High-grade sulphate of potash	4.7	

(3) *The guaranteed chemical composition and relative commercial values of merchantable fertilizers* (pp. 45-82).

From the Station's stand-point this subject involves (1) the sampling; (2) the laboratory work.

Previous to the year 1884 all samples of fertilizers analyzed in this laboratory were drawn either by the Station's officials or by reputable farmers who had reasons for suspecting the quality of the brands bought for their own use. This system had many disadvantages and has been abandoned. At present the only samples received for analysis are those taken by duly authorized inspectors.

This plan has been satisfactory to both consumers and producers, for the inspectors are, without exception, farmers of the highest standing, who undertake the work solely because it is regarded as a matter of vital interest to the farming community.

At the beginning of the season each inspector was furnished with a sampling-tube, blanks for describing samples, bottle-labels, etc., together with printed instructions regarding their uses, and each inspector was requested to secure a sample of every brand of complete fertilizer which he could find in his district. As fast as samples were found they were shipped to New Brunswick, where they were properly numbered and stored.

A copy of the instructions, under which all samples were taken, is as follows:

DIRECTIONS TO BE OBSERVED IN SAMPLING FERTILIZERS.

Inspectors may sample fertilizers found either (1) upon farms; (2) in dealers' store-houses; or (3) in manufactories.

The Station prefers that samples should be drawn either upon farms or in dealers' store-houses.

In sampling fertilizers found upon farms inspectors should ascertain (1) that the farmer has received these fertilizers *during the present season*; (2) that they were received in good condition, and have since been so stored that a noticeable gain or loss of moisture has been prevented.

In no case should farm samples be taken from stock of a past season or from stock which is or has been carelessly stored.

In sampling from *dealers' store-houses* inspectors should also ascertain whether the fertilizers are of old (last season's) or of new stock. Preference should always be given to the present season's goods. Circumstances may, however, make it advisable to sample old stock; in such cases this fact should be distinctly stated by the inspector in his report to the Station's director.

If for any reason it is found to be necessary to draw samples at factories inspectors should decline (1) to sample from piles of fertilizers; (2) to sample from bags which are not distinctly marked with the brand, the manufacturer's name, and the guaranteed analysis.

If fertilizers are found stored in piles only, inspectors should cause six or more bags to be filled from different portions of the piles; from these bags the samples may be drawn in the usual manner.

SAMPLING.

Whenever the mechanical condition will allow, samples should be drawn by means of the *sampling tube*.

This tube is formed to a sharp point at one end, and can be forced to the bottom of a bag or barrel. A slot extending nearly its entire length can then be opened and the tube allowed to fill with the fertilizer. When the slot is closed and the tube withdrawn, it will contain a fair sample of any given package.

It is not desirable to sample lots of less than one-half ton of any one brand. In such lots portions may be taken from each bag; in larger lots each fifth or tenth bag may be opened. The several portions representing the same brand should then be carefully mixed and a quart fruit-jar filled, securely closed, and marked with labels furnished by the Station.

As soon as a sample has been taken, and invariably before bags of another brand have been opened, the inspector should carefully fill out the blank describing samples.

He should copy from the bags (1) the brand; (2) the name of the manufacturer; (3) the guaranteed analysis.

Any other information desired can be sought from the owner of the fertilizer.

Each sample bottle should be carefully wrapped in heavy paper, and packed for transportation in a wooden box, properly closed. This box should be forwarded by express, directed to "The New Jersey Agricultural Experiment Station, Geo. H. Cook, Director, New Brunswick, N. J."

The report contains a copy of the directions under which samples were taken, and an account of the rules followed in the laboratory.

Out of 170 samples, 96 have been found to contain more plant food of all kinds than their manufacturers claim, while 4 fall below their guarantees in every respect. Fifty-six per cent, therefore, of the samples tested are up to the standard, and 2.5 per cent are, in all respects, below grade. These results are practically identical with those secured in 1885, 1886, and 1887.

Of the remaining samples, 70 in number, some contain excessive amounts of one or more elements, and fall below their claims in other respects, indicating careless work in the factories. Others show that the State law which regulates the method of analyzing fertilizers has been ignored, but in no case has proof been secured of a deliberate attempt to defraud.

During the past year four bulletins containing fertilizer analyses have been published:

No. XLV. Devoted to prices of nitrogen, phosphoric acid, and potash for 1888.

XLVII. Devoted to fertilizer supplies.

XLVIII. Devoted to complete fertilizers.

XLIX. Devoted to complete fertilizers, ground bone, and miscellaneous fertilizers.

The circulation of these publications approximated 8,500 copies in this State alone.

In addition to the 78 samples reported on in pp. 39-45, the report contains tables giving the details of the results of analyses of 170 samples of complete fertilizers, 19 of ground bone, 3 of dissolved bone, and 11 of miscellaneous products (pp. 54-81).

Agricultural relations of fertilizers (pp. 82-104).

This field of scientific research is wide, and individual experiments, from the nature of the work, are usually confined to groups of specific and definite questions. The principal methods used in attempts to solve these questions are (1) field experiments and (2) pot experiments. The relative value of these two methods of investigation is at the present time not entirely settled. Both methods, however, have supplemented each other to a considerable extent, and by their aid many scientific facts have been demonstrated, and hence many valuable data secured, capable of application by the practical farmer. The field of agricultural experimentation is, nevertheless, still practically unlimited.

The equipment of this Station has rendered field experiments with fertilizers the only feasible method to be followed. Since 1881 these experiments have numbered more than sixty, have been distributed upon the radically different soils of the State, and have included all the staple farm crops grown in New Jersey. In this work several distinct ends have been kept in view, and detailed statements of results have been published from time to time in previous reports of this Station. Definite conclusions thus far reached can be grouped as follows:

(1) Profitable returns cannot always be secured, even when the highest grades of fertilizers are used throughout an entire rotation.

(2) Fertilizers, when used upon suitable soils, secure immediate profits and also materially benefit the land.

Field experiments (pp. 83-89), begun in 1882 by A. P. Arnold, Vine-land, Cumberland County, to determine—

- I. *The effect of barn-yard manure upon a rotation of crops, compared with the effects of the leading elements of plant food used separately and in combinations.*
- II. *The financial results which follow the use of commercial fertilizers.*

A description of this farm and its management was given in the annual report of this Station for 1886; it indicated that dairying was not followed to any marked extent, and that a very limited supply of manure was produced; that fertilizers were used successfully, and that the tendency at present was against complete manures and in favor of acid phosphates and potash salts.

It was shown that a four-year rotation was followed, viz, corn, sweet potatoes, clover and millet, and clover; the object being to keep the ground in good condition for the potatoes, from which the profits of the rotation were secured, the income from this crop being equal to that received from the other three combined.

The field was selected for this work in 1882; at that time it was in blackberries. It was prepared for corn in the usual manner, and eleven plats, each one-tenth of an acre in area, were staked off in a favorable location. The kinds and quantities of plant-food used in 1882 upon each plat can be learned from a following table. During the succeeding years of the rotation every crop was fertilized, but no changes of any kind were made in the original plan. Plat 11, therefore, received during the rotation 80 tons of stable manure per acre. In like manner, plat 4 received 600 pounds of muriate of potash; plat 3, 1,400 pounds of bone-black superphosphate; plat 9, 2,600 pounds of a high-grade potato fertilizer per acre, etc., in each case one-quarter of the above weights having been used broadcast annually.

At the close of the first rotation the following conclusions were reached:

(1) The total market value of the four crops grown without manure or fertilizer averaged \$55.30 per acre.

(2) At a total expense, for nitrate of soda, of \$16.20 per acre, the income was in-

creased to \$70.95; the cash which was advanced for the fertilizer was therefore recovered, but no profits were made. When \$14.68 was expended per acre for superphosphates the total income was \$63.09; the use of this material consequently resulted in a loss of \$6.89 per acre.

(3) Potash, used alone on plat 4, influenced the profits in a very marked manner; the increased returns from its use were sufficient to leave a balance of \$21.59 after fertilizer charges had been met and due credit allowed for the product from the unmanured ground. *Twenty-one dollars and fifty-nine cents is 180 per cent of \$12, the cost of 600 pounds of muriate of potash.*

(4) Plats 7 and 8, upon which potash was used in combination with nitrogen and phosphoric acid, respectively, also gave profitable crops, the net gains being \$23.16 in one case and \$24.48 in the other. The combination of nitrogen, phosphoric acid, and potash (plat 9) called for the largest investment but yielded the largest net profit, viz, \$47.03, or 110 per cent of \$42.80, the market value of 2,600 pounds of a complete potato manure.

(5) During a period of four years Mr. Arnold used 80 tons of stable manure per acre upon plat 11, and converted it into crops worth \$177.82. During the same period, without the aid of fertilizers, a portion of the same field in the same crops gave returns worth \$55.30. The value of the manure may therefore be estimated at \$122.52 or a fraction more than \$1.50 per ton.

The manure, of course, caused a marked improvement in the fertility of the field, but the value of this improvement cannot at present be definitely expressed. To study this point a second rotation has been commenced upon the same plats, its first crop, Indian corn, having been gathered in 1886, and its second, sweet potatoes, in 1887; its third crop, millet, is herewith reported:

FIELD EXPERIMENTS WITH FERTILIZERS ON MILLET.

(By A. P. Arnold, Vineland, Cumberland County, N. J.)

No. of plat.	Fertilizers.			Pounds of millet per acre.	Value of millet per acre.	Net gain or loss.
	Kind.	Weight per acre.	Cost per acre.			
1	Nothing .....	.....	.....	890	\$4.45	.....
2	Nitrate of soda	150 pounds.....	\$4.05	1,750	8.75	+\$0.73
3	Superphosphate	350 pounds.....	3.67	880	4.40	—3.24
4	Muriate of potash	150 pounds.....	3.00	720	3.60	—3.37
5	{ Nitrate of soda	150 pounds.....	7.72	2,210	11.05	—0.64
	{ Superphosphate	350 pounds.....				
6	Nothing .....	.....	.....	700	3.50	.....
7	{ Nitrate of soda	150 pounds.....	7.00	2,150	10.75	—0.22
	{ Muriate of potash					
8	{ Superphosphate	350 pounds	6.67	1,380	6.90	—3.74
	{ Muriate of potash	150 pounds.....				
9	{ Nitrate of soda	150 pounds.....	10.72	2,920	14.60	—0.09
	{ Superphosphate	350 pounds.....				
	{ Muriate of potash	150 pounds.....				
10	Plaster	400 pounds.....	1.50	640	3.20	—2.27
11	Fine barn-yard manure.....	20 two-horse loads.	30.00	5,570	27.85	—6.12

It has been stated above that these plats were selected in 1882, and that since this time the original plan has been followed without changes of any kind. Plats 1 and 6 have therefore received no plant food from manure or from fertilizers for seven years; plat 11, on the other hand, has been dressed with 140 tons of yard manure per acre, and plat 9 has had per acre over 2 tons of a high-grade potato manure. The total amounts of plant food used upon the other experiments during the same period may be learned by multiplying by seven the weights of fertilizer per acre published in the above table for each of said plats.

The fertilizers were applied about the middle of April, and at the same time the plats were seeded with millet and clover at the rate of 1 bushel each upon 6 acres. Mr. Arnold reports that upon plats 1, 3, 4, 6, 8, and 10 the product was largely crab-

grass, and that the clover was a good catch only upon plats 8 and 11. In computing values, however, the product of each plat has been regarded as of the same quality, and the market value of millet in that section, viz, \$10 per ton, has been used. The yields from plats 1 and 6 agree fairly well. A comparison of the average yield of those plats with yields from plats 3, 4, and 10 indicates that phosphoric acid, potash, and plaster have practically no effect when used alone. A noticeable increase is observed, however, in plat 8 from the combination of superphosphate with muriate of potash. A very favorable influence on both catch and yield is exerted by nitrogen wherever used. Used alone it increased the yield over that of the unmanured plots by 120 per cent, while only securing a profit of 73 cents; a financial loss followed the use of fertilizers in every other case. The financial values have been computed to serve as an aid in comparison of yields, rather than as an indication of profits or losses. Mr. Arnold's letter concerning the value of millet is here republished from the fifth annual report of this Station.

He writes in substance as follows: "In making this report I do not wish it to be understood that a crop of millet was sought as a direct source of profit. Our problem here is to secure a clover sod upon which to grow a corn crop. If clover seed is sown alone weeds take possession of the ground at first, and make the small amount of clover which is secured by late cutting of comparatively little value.

"By sowing millet and clover together I secure fodder which my stock consume as readily as they do baled hay, worth here \$20 per ton. My clover, too, is not inferior to that secured by others who seed down without millet and receive little or no benefit from the first cut because of weeds."

No. of plat.	Kind of fertilizers.	Value of crops.					
		Corn.		Sweet potatoes.		Clover and millet.	Millet.
		1882.	1886.	1883.	1887.	1884.	1888.
1	Nothing.....	\$16.14	\$15.14	\$25.85	\$18.98	\$4.55	\$4.45
2	Nitrate of soda.....	21.28	18.67	25.61	17.18	10.05	8.75
3	Superphosphate.....	15.96	20.50	29.93	11.79	5.30	4.40
4	Muriate of potash.....	14.84	20.88	56.41	87.45	5.10	3.60
5	{ Nitrate of soda.....	20.86	28.12	30.60	13.24	11.05	11.05
6	{ Superphosphate.....						
7	Nothing.....	13.37	17.52	29.07	18.68	4.85	3.50
8	{ Nitrate of soda.....	23.17	25.18	52.65	72.16	12.15	10.75
9	{ Muriate of potash.....						
10	{ Superphosphate.....	15.79	25.09	65.77	81.60	6.00	6.90
11	{ Muriate of potash.....						
12	{ Nitrate of soda.....	22.05	33.29	75.76	103.10	16.40	14.60
13	{ Superphosphate.....						
14	{ Muriate of potash.....	14.49	12.69	20.08	16.89	5.35	3.20
15	{ Plaster.....						
16	Fine barn-yard manure.....	23.45	40.06	85.45	210.38	17.90	27.85

In the above table the corn crop grown in 1886, the sweet potatoes grown in 1887, and the millet grown in 1888 are compared with similar crops grown upon the same plats in 1882, 1883, and 1884, in order to determine roughly the loss or gain of fertility due to the persistent use of barn-yard manure and commercial fertilizers. Conclusions drawn from a comparison of the sweet-potato crops, and published in the report of this Station for 1887, showed that wherever potash had been used the improvements in the value of the crop varied from 8 per cent to 107 per cent, and that an improvement of 35 per cent in the crop-producing power of the land had therefore been gained without sacrifice of any kind. In all cases where potash was excluded the decrease in the value of the second potato crop was serious, ranging from 36 to 63 per cent. The value of barn-yard manure in improving the crop-producing power of the land was estimated at \$2.74 per ton.

A comparison of the crops of millet upon these plats shows an improvement of the soil in only two cases, plat 8 yielding 15 per cent and plat 11, 56 per cent more in

1888 than in 1884. On all the other plats the decrease in the yield ranges from 2 to 40 per cent. These results seem to indicate that the sweet-potato crop immediately preceding consumed all the crop-producing power that the soil had acquired up to that time, leaving the land in about the same condition of fertility as it was four years previous. Upon the eleventh plat, however, the accumulation of reserve plant food from the annual addition of 20 tons of barn-yard manure seemed to have been sufficiently great to double the yield of sweet potatoes and afterwards increased the yield of millet 56 per cent. In comparing the two crops of millet, its value has been estimated on the basis of \$10 per ton in both cases.

The complete record of Mr. Arnold's work up to date is here published in tabular form.

Number of plat.	Kind of fertilizer.	Weight per acre used annually in 1882, 1883, 1884, 1885, 1886, and 1887.	Yield per acre.				
			1882.		1883.		1884.
			Corn.		Sweet potatoes.		Clover and millet.
			Shelled corn.	Stalks.	Good.	Poor.	
		<i>Pounds.</i>	<i>Bush.</i>	<i>Lbs.</i>	<i>Bush.</i>	<i>Bush.</i>	<i>Lbs.</i>
1	Nothing.....	.....	15.8	1,450	25.0	33.4	910
2	Nitrate of soda.....	150	22.7	1,540	25.8	30.2	2,010
3	Superphosphate.....	350	15.0	1,560	29.4	37.4	1,060
4	Muriate of potash.....	150	13.7	1,500	72.8	21.8	1,020
5	{ Nitrate of soda.....	150 }	20.7	1,820	32.0	32.8	2,210
	{ Superphosphate.....	350 }					
6	Nothing.....	.....	11.7	1,480	30.6	30.6	970
7	{ Nitrate of soda.....	150 }	25.1	1,600	65.0	28.6	2,430
	{ Muriate of potash.....	150 }					
8	{ Superphosphate.....	350 }	14.4	1,630	80.6	37.2	1,200
	{ Muriate of potash.....	150 }					
9	{ Nitrate of soda.....	150 }	23.1	1,680	92.8	43.2	3,280
	{ Superphosphate.....	350 }					
	{ Muriate of potash.....	150 }	13.8	1,380	16.4	34.4	1,070
10	Plaster.....	400					
11	Fine barn-yard manure.....	(*)	24.5	1,800	108.0	35.4	3,580

Number of plat.	Kind of fertilizer.	Weight per acre used annually in 1882, 1883, 1884, 1885, 1886, and 1887.	Yield per acre.						
			1885.			1886.		1887.	
			Clover hay.			Corn.		Sweet potatoes.	
			First cut.	Second cut.	Total weight.	Shelled corn.	Stalks.	Good.	Poor.
		<i>Pounds.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Bush.</i>	<i>Lbs.</i>	<i>Bush.</i>	<i>Bush.</i>
1	Nothing.....	.....	440	210	650	12.1	2,770	11.8	31.8
2	Nitrate of soda.....	150	450	210	660	19.4	2,840	13.0	22.6
3	Superphosphate.....	350	680	420	1,100	14.5	3,990	3.0	31.3
4	Muriate of potash.....	150	810	430	1,240	14.2	4,140	96.0	35.5
5	{ Nitrate of soda.....	150 }	1,070	440	1,510	29.9	4,190	7.7	23.6
	{ Superphosphate.....	350 }							
6	Nothing.....	.....	460	120	580	15.2	3,050	10.6	34.0
7	{ Nitrate of soda.....	150 }	760	330	1,090	25.0	3,980	79.7	28.0
	{ Muriate of potash.....	150 }							
8	{ Superphosphate.....	350 }	1,530	620	2,150	13.3	5,460	90.0	32.0
	{ Muriate of potash.....	150 }							
9	{ Nitrate of soda.....	150 }	1,680	740	2,420	32.2	5,370	118.0	29.0
	{ Superphosphate.....	350 }							
	{ Muriate of potash.....	150 }	390	390	780	8.3	2,560	9.3	31.5
10	Plaster.....	400							
11	Fine barn-yard manure.....	(*)	3,160	2,360	5,520	46.7	5,440	240.4	30.2

* Twenty two-horse loads.

Field experiments with fertilizers on peach trees (pp. 90-97), begun in 1884 by S. C. Dayton, Basking Ridge, Somerset County, N. J. In the first, corn was planted in the orchard; in the second, buckwheat; in the third, fourth and fifth the ground was given up to the trees. The orchard came into bearing in 1887. The following table summarizes the results of the experiments, the details of which are given in this and preceding reports :

Number of plat.	Fertilizers.			Value of crop.		Value of three crops.	Value of four crops.
	Kind.	Weight per acre per year, 1884, 1885, 1886, 1887.	Cost per acre per year.	Peaches, 1887.	Peaches, 1888.		
		<i>Pounds.</i>					
1	Nothing			\$53.30	\$79.30	\$83.35	\$162.65
2	Nitrate of soda	150	\$4.05	40.80	75.00	74.54	149.54
3	Superphosphate	350	3.67	81.25	112.45	136.74	249.19
4	Muriate of potash	150	3.00	61.75	115.05	95.48	210.53
5	{ Nitrate of soda	150 } 500	7.72	70.35	172.25	125.78	301.03
6	{ Superphosphate	350 }					
7	Nothing			60.00	127.50	93.46	220.96
8	{ Nitrate of soda	150 } 300	7.05	56.90	147.50	88.74	236.24
9	{ Muriate of potash	150 }					
10	{ Superphosphate	350 } 500	6.67	86.80	161.25	147.39	308.64
11	{ Muriate of potash	150 }					
12	{ Nitrate of soda	150 } 650	10.72	76.10	209.30	128.50	347.80
	{ Superphosphate	350 }					
	{ Muriate of potash	150 }					
10	Plaster	400	1.50	65.65	142.85	105.68	248.53
11	Fine barn-yard manure	{ 20 2-horse } 30.00		73.80	235.95	139.15	375.10
		{ loads. }					
12	{ Barn-yard manure	10 loads. }		31.20	133.90	86.47	220.37
	{ Lime	50 bushels }					

Number of plat.	Fertilizers.			Cost of fertilizers for four years.	Cost of fertilizers for five years.	Profit or loss for four years.	Profit or loss for five years.	Increase in value by crop of 1888.	Profit or loss for four years.	Profit or loss for five years.
	Kind.	Weight per acre per year, 1884, 1885, 1886, 1887.	Cost per acre per year.							
		<i>Pounds.</i>						<i>P. ct.</i>	<i>Per ct.</i>	<i>P. ct.</i>
1	Nothing							95		
2	Nitrate of soda	150	\$4.05	\$16.20	\$20.25	-\$30.06	-\$62.51	101	- 185.0	- 300
3	Superphosphate	350	3.67	14.68	18.35	+ 33.66	+ 39.04	82	+ 229.0	+ 212
4	Muriate of potash	150	3.00	12.00	15.00	- 4.92	+ 3.73	120	- 41.0	+ 25
5	{ Nitrate of soda	150 } 500	7.72	30.88	38.60	+ 9.50	+ 70.63	133	+ 30.7	+ 183
6	{ Superphosphate	350 }						136		
7	Nothing									
8	{ Nitrate of soda	150 } 300	7.05	28.20	35.25	- 17.86	+ 9.09	166	- 63.3	+ 25
9	{ Muriate of potash	150 }								
10	{ Superphosphate	350 } 500	6.67	26.68	33.35	+ 32.21	+ 83.49	109	+ 120.0	+ 250
11	{ Muriate of potash	150 }								
12	{ Nitrate of soda	150 } 650	10.72	42.88	53.60	+ 7.22	+ 102.40	143	+ 16.8	+ 191
	{ Superphosphate	350 }								
	{ Muriate of potash	150 }								
10	Plaster	400	1.50	6.00	7.50	+ 11.28	+ 49.23	135	+ 188.0	+ 656
11	Fine barn-yard manure	{ 20 2-horse } 30.00		120.00	150.00	- 69.25	+ 33.30	168	- 57.7	+ 22
		{ loads. }								
12	{ Barn-yard manure	10 loads. }		82.40	103.00	- 84.33	- 74.43	154	- 102.0	- 72
	{ Lime	50 bushels }								

Field trials with Canadian ashes, domestic ashes, dissolved South Carolina rock, and Orchillo guano (pp. 98, 99), begun in 1885 by A. P. Arnold, Vineland; the experiments are not yet completed.

Field experiments with fertilizers on corn, 1886, oats, 1887, and wheat, 1888, by Theo. West, on the college farm (pp. 100, 101), were planned to show—

- (1) The variations in yields between unmanured plots;
- (2) The effects both of barn-yard manure and commercial fertilizers upon the growth of corn, oats, wheat, and grass.

Field trials upon wheat to test the relative value of phosphoric acid derived from bone-black, bone-ash, and South Carolina rock (pp. 101–104). These experiments were made at the request of the Salem County Board of Agriculture, expressed as follows:

At a late meeting of the Salem County Board of Agriculture the following preamble and resolutions were adopted, viz:

Whereas dissolved South Carolina rock is a much cheaper source of phosphoric acid than dissolved bone; and

Whereas the value of the first to the crop subsequent to that to which it is applied is questioned;

Resolved, That the Salem County Board of Agriculture request our Experiment Station to carry out such experiments as will decide the relative agricultural value of phosphoric acid from dissolved rock and dissolved bone.

H. C. PERRY,
Secretary.

ALLOWAY, May 11, 1887.

Lucern, or Alfalfa (pp. 105–113).

In the spring of 1887 a circular was issued by this Station, in which lucern, or alfalfa, and the claims made for it as a fodder plant, were described substantially as follows:

Alfalfa is a forage plant, which closely resembles clover, not only in feeding value, but also in its habits of growth and effects upon following crops. It has been cultivated in Europe for nearly two thousand years, and is now well known both in North and South America. In California, in particular, its importance is fully appreciated by stockmen.

For New Jersey it is claimed that in comparison with red clover alfalfa has the following advantages:

- (1) It is fit for soiling purposes as early as the third week in May.
- (2) It may be cut three or four times each season.
- (3) The second and later growths, if harvested as soon as blossoms appear, make an excellent hay.
- (4) When well rooted it successfully resists both drought and frost.
- (5) Under favorable conditions it does not "run out" for many years.

It has been grown in the Eastern and Middle States ever since 1791, but in spite of its apparent advantages it has never been in general use. For this numerous explanations are offered, among which the following may be noted:

- (1) The first growth is fit to cut before the weather is suitable for hay-making. If allowed to mature, the stems grow woody and are rejected by stock.
- (2) Trouble has been experienced in securing a good stand.

These advantages and alleged disadvantages warranted the Station in planning a series of experiments, to test its value upon the different soils of New Jersey. Ten experiments, therefore, were then begun, distributed among seven counties of the State. Of these the one upon the college farm alone has proved successful. Its success is believed to be due almost entirely to the fact that it was the first one seeded, and was from the start aided by favorable weather and tillage. The details of this experiment are as follows:

Plan of experiment.—A plat 30 feet wide and 150 feet long was carefully prepared.

It had been in corn the preceding year, and, as the subsoil is a rather compact clay, it was not believed to be specially fitted for alfalfa. Eighty pounds of a complete fertilizer having an unusually high percentage of nitrogen and potash were spread upon it broadcast. Approximately one-half of the plat was then seeded in drills at the rate of 15 pounds of seed per acre; the rows were 14 inches apart. The other half of the plat was seeded broadcast at the rate of 30 pounds of seed per acre.

Report on the second year's growth of alfalfa upon the college farm.—Upon the 27th of April, 1888, 50 pounds of a complete fertilizer—analyzing 2.79 per cent total nitrogen, 10.87 per cent total phosphoric acid, 7.69 per cent available phosphoric acid, and 4.22 per cent potash—were broadcasted upon the two plats of alfalfa, which at this time showed a thick stand and was growing rapidly and vigorously. Clover had not yet made any start.

Upon May 10 the drilled plat was cultivated; the alfalfa then had a height of 15½ inches. Upon May 19 its growth had become very heavy, but it showed no blossoms. It has been demonstrated that the best results are secured from alfalfa when it is cut just after the blossoms have appeared. In order to wait for this stage in its growth, therefore, and also because the weather was almost continuously wet or cloudy, the crop was left untouched until June 4, when the first cutting was secured; even at this date no blossoms were visible, although blossom buds were plainly developed. The maximum height of the alfalfa at this time was 40 inches, the average length of the plants being about 32 inches. Both plats were quite free from weeds, and no dodder was visible. Clean mowing was very difficult, owing to the alfalfa being very much down and twisted, this being the case especially with the drilled plat. The yield was 9.3 tons of green fodder per acre on the drilled plat and 9.9 tons per acre on the broadcasted plat.

On June 15 the drilled plat was again cultivated. The alfalfa was then again 10 inches high. Blossoms began to appear June 30, and on July 5, when it was in full bloom, the second cutting was secured. Its height was then 20 inches upon the drilled and 18 inches upon the broadcasted plat, but upon the latter the growth was thicker and just as free from weeds. The yield was 4.4 tons of green fodder per acre on each plat, this growth having been made during an interval of thirty days.

The third cutting was secured on August 6, at which time the alfalfa had an average height of only 8 inches, and looked very badly. Its leaves had turned yellow; no dodder was visible; the broadcasted plat contained a great deal of plaintain. The yield of green fodder per acre was 2.1 tons on the drilled and 2.4 tons on the broadcasted plat.

On August 6, immediately after the third cut was secured, the two plats received an application of 35 pounds of bone-black superphosphate and 15 pounds of muriate of potash. On August 28 there was a fine, vigorous growth of 16 inches, which on September 14 had increased to 22 inches. Although very few blossoms were visible as yet, the alfalfa was cut for the fourth time, and yielded 3 tons per acre on the drilled and 4.2 tons per acre on the broadcasted plat.

Following this cutting there was a rank growth, which would have yielded a good crop early in October, had it not been deemed best to omit further cutting this season, pasturing lightly instead. The total yield of green fodder per acre during the season of 1888, therefore, was 18.8 tons from the drilled plat and 20.9 tons from the broadcasted plat.

At the beginning of winter the alfalfa showed a good stand, although bare spots could be seen in parts of the drilled plat, and plaintain had taken possession of a small spot in the center of the broadcasted plat. It is believed that the delay in cutting the first crop this season materially injured the subsequent crops.

Chemical composition of this crop.—Each cut of alfalfa was sampled immediately after the crop was secured. The analyses of these samples are as follows:

Station No.		Tonnage per acre.	Pounds per hundred of—						Percentage of—		
			Water.	Fat.	Fiber.	Ash.	Protein.	Carbohydrates.	Nitrogen.	Phosphoric acid.	Potash.
454	First cut, drilled	9.30	79.46	0.89	5.00	2.03	4.17	8.45	0.67	0.14	0.69
455	First cut, broadcast	9.90	80.61	0.79	4.48	2.04	4.02	8.06	0.64	0.13	0.78
456	Second cut, drilled	4.35	64.37	1.33	6.54	2.81	5.43	19.52	0.87	0.19	0.91
457	Second cut, broadcast	4.41	61.69	1.24	9.08	3.15	6.42	18.42	1.03	0.20	0.89
458	Third cut, drilled	2.05	69.41	1.29	5.58	2.81	5.42	15.49	0.87	0.10	0.80
459	Third cut, broadcast	2.40	72.45	0.91	5.95	2.70	4.86	13.13	0.78	0.12	0.80
460	Fourth cut, drilled	3.00	77.44	1.16	4.75	2.38	4.90	9.37	0.79	0.14	0.74
461	Fourth cut, broadcast	4.15	78.33	1.26	4.68	2.26	4.26	9.21	0.68	0.15	0.70
	Total tonnage per acre and average composition of crop on drilled plat	18.70	72.67	1.17	5.47	2.51	4.98	13.21	0.80	0.14	0.80
	Total tonnage per acre and average composition of crop on broadcast plat	20.86	73.27	1.05	6.03	2.54	4.79	12.21	0.78	0.15	0.79

No marked differences are noticed in the composition of the alfalfa from the two plats. The total yield on the broadcast plat was 11.5 per cent greater than on the drilled plat.

The following table shows the yields and average composition of the alfalfa from the drilled plat for 1887 and 1888, and from the broadcasted plat for 1888. These have been calculated to the hay basis for the purpose of comparing with clover, which is everywhere recognized to be one of the most valuable plants grown in its various relations to agriculture:

	Tonnage per acre.	Pounds per hundred of —						Percentage of —		
		Water.	Crude fat.	Crude fiber.	Ash.	Crude protein.	Carbohydrates.	Nitrogen.	Phosphoric acid.	Potash.
1887. Drilled plat	20.79	80.34	0.83	4.51	2.07	3.82	8.44	0.61	0.11	0.69
1888. Drilled plat	18.70	72.67	1.17	5.47	2.51	4.98	13.21	0.80	0.14	0.80
1888. Broadcasted plat	20.86	73.27	1.05	6.03	2.54	4.79	12.21	0.78	0.15	0.79
1887. Drilled plat on the hay basis.	4.44	7.70	3.89	21.17	9.80	17.93	39.62	2.90	0.52	3.24
1888. Drilled plat on the hay basis.	5.54	7.70	3.95	18.47	8.48	16.82	44.61	2.70	0.47	2.70
1888. Broadcasted plat on the hay basis	6.04	7.70	3.63	20.82	8.77	16.54	42.16	2.69	0.52	2.73
Average composition of clover hay		7.70	2.08	28.20	6.80	12.46	42.77	1.99	0.36	1.68

The table shows that 39.49 tons of the green alfalfa on the drilled plat would dry to 9.98 tons of hay, and that 20.86 tons on the broadcast plat would dry to 6.04 tons. Since no cuts were made on the broadcast plat in 1887, there remains a balance to the credit of the drilled plat of 3.94 tons, which, exclusive of the cost of cultivating and hoeing, represents to this date the advantage of seeding in drills over broadcast seeding. The drilled plat was cultivated five times and hoed once during the first year's growth in 1887; in 1888 it was cultivated but three times. An exact record of the cost of this cultivating and hoeing has not been kept, but it is estimated to be not more expensive, with proper tools, than the cultivation of field corn.

Alfalfa considered as a food in comparison with clover and timothy.

Drilled plot.	Tonnage on the hay basis.	Fat.	Fiber.	Protein.	Carbohydrates.	Feeding value of crop per acre.
		<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	
1887. Total	4.44	345.1	1,875.2	1,588.4	3,509.4	.....
1887. Digestible		155.3	768.9	1,286.6	2,526.8	92.15
1888. Total	5.44	437.6	2,045.8	1,862.5	4,940.5	.....
1888. Digestible		196.9	838.8	1,508.6	3,557.2	113.50
Total for two years	9.88	782.7	3,921.1	3,450.9	8,449.9	.....
Total digestible for two years		352.2	1,607.7	2,795.2	6,084.0	205.65
Average amounts of digestible food and value per ton of lucern hay		35.3	161.1	280.1	609.6	20.60
Average amounts of digestible food and value per ton of clover hay		33.6	316.6	167.0	569.0	14.20
Average amounts of digestible food and value per ton of timothy hay		24.4	357.0	68.0	566.4	12.40

The above table shows the total and the digestible food per acre secured from the drilled plat in 1887 and 1888, and its feeding value. As a means of ready comparison of yields, and also of feeding value when compared with the principal hay crops grown in New Jersey, a money value has been placed upon the digestible protein, fat, and carbohydrates. The prices assumed are 4.3 cents per pound for protein and fat, and nine-tenths of a cent per pound for carbohydrates, including fiber. The total yield for the two years has an estimated feeding value of over \$200, the value of the second crop exceeding that of the first by \$21.35. The total yield for the two years is approximately 10 tons of dry hay, with a feeding value of \$20.60 per ton.

In the above table clover and timothy are added as representing, in the case of clover, the hay usually fed upon the farm, and in the case of timothy, the hay very largely sold from it. The table shows that alfalfa hay is, in money value, 45 per cent better than clover, and 66 per cent better than timothy. The actual feeding value of any one of them, however, depends upon the proper balancing of the different classes of compounds. To secure a good milk ration by the use of timothy hay, protein must be supplied from some other source in order to secure a ration that will give a sufficient amount of that material without entailing a loss of carbohydrates and fat; clover hay, however, is a fairly good ration in itself, and can be economically used without the addition of any one of the classes of compounds mentioned; alfalfa hay, on the other hand, requires the addition of large amounts of both fat and carbohydrates in order to be profitably utilized as a milk ration. This fact renders alfalfa even more serviceable than its valuation would indicate, since, in the management of farms either for dairy purposes or for grain farming, an excess of carbohydrates is secured which in the great majority of cases is wasted, either through lack of proper material from other sources with which to balance the ration, or through ignorance of the real loss incurred.

Under ordinary conditions, $2\frac{1}{2}$ pounds of protein, four-tenths of a pound of fat, and $12\frac{1}{2}$ pounds of carbohydrates can be profitably fed daily to a milch cow of 1,000 pounds live weight. One ton of alfalfa hay, containing 35.3 pounds of digestible fat, 280.1 pounds of digestible protein, and 770.7 pounds of digestible carbohydrates, would furnish sufficient protein for *one hundred and twelve* days, fat for *eighty-eight* days, and carbohydrates for *sixty-one* days. Therefore, in order to feed this amount of alfalfa economically and profitably, fat sufficient for twenty-four days, and carbohydrates for fifty-one days must be added from some other source. In securing these amounts of fat and carbohydrates it is impossible to avoid adding protein to a slight extent, since all farm products that are of any value for feeding purposes contain more or less protein; this addition of protein, however, may be, and should be, reduced to a min-

imum by the selection of those materials which contain it in the smallest amounts. Among these may be mentioned field corn-stalks, green fodder corn or ensilage, wheat straw, oat straw, root crops, etc.

One ton of field corn-stalks, containing 17 pounds of fat, 60 pounds of protein, and 1,076.6 pounds of carbohydrates, would furnish sufficient protein for twenty-four days, fat for forty days, and carbohydrates for eighty-six days. Two tons of a mixture of equal weights of field corn-stalks and alfalfa would therefore furnish food sufficient for one hundred and thirty-six days without noticeable loss of any of the digestible compounds.

In the case of corn ensilage, every ton of which contains 6 pounds of fat, 24.4 pounds of protein, and 296.6 pounds of carbohydrates, 3 tons would furnish sufficient protein for twenty-eight days, fat for forty-five days, and carbohydrates for seventy-one days. Four tons of a mixture composed of 1 ton of alfalfa hay and 3 tons of ensilage, or green fodder corn, would therefore furnish food sufficient for one hundred and thirty-six days without any appreciable loss. By the aid of the feeding tables, upon subsequent pages, other materials could be substituted which would secure results similar to those in the examples just given.

Alfalfa, therefore, furnishes the farmer a feeding material rich in protein, which can be substituted for such waste products as wheat bran, cotton-seed meal, etc., usually bought in order to profitably utilize the excess of carbohydrates.

Alfalfa considered as a collector of plant-food.—The extraordinary demands made upon available plant-food by a crop of alfalfa were referred to in the annual report of this Station for 1886. These demands are especially noticeable in the case of nitrogen and potash, the crops of 1887 and 1888 together having collected over one-quarter of a ton of each. Including the barn-yard manure applied previous to seeding, the total amount of plant-food applied to this crop has not exceeded 150 pounds each of nitrogen, phosphoric acid, and potash.

It is universally admitted that the mineral constituents of plants, as phosphoric acid, potash, lime, etc., are derived solely and entirely from the soil. In the case of nitrogen, however, it has long been asserted, and is now claimed to be positively proven, that certain leguminous plants, as clover, peas, alfalfa, etc., have the power of assimilating large amounts from the atmosphere when sufficient phosphoric acid, potash, and lime are present in the soil.

Therefore, while it is quite possible that alfalfa, being a deep-rooting plant, could secure all this nitrogen from the soil, the probability that it has secured a large quantity from the air enhances its value as an agricultural plant, firstly, because nitrogen is the basis of the compound protein, the most valuable part of the food product, and secondly, because nitrogen is the most costly element in fertilizing compounds.

Alfalfa serves, therefore, not only as a manufacturer of the chief element of food, but also a collector from sources otherwise inaccessible of the most valuable fertilizing agent for a large class of agricultural plants whose only source of nitrogen is in the soil. It acts in the hands of the farmer as an agent for rendering locked-up capital available.

When alfalfa is grown and its products are properly utilized upon the farm, it can not be considered an exhaustive crop, but rather as one fulfilling the proper aim of rational agriculture, which is to transform into produce the raw materials at our disposal in the atmosphere and soil.

Amount of plant-food collected from one acre, and its value in the form of nitrate of soda, bone-black superphosphate, and muriate of potash.

Drilled plat.	Pounds per acre of—			Fertilizing value at present prices.
	Nitrogen.	Phosphoric acid.	Potash.	
In 1887	253.6	45.7	286.9	\$57.70
In 1888	299.2	52.4	292.2	66.30
Total	552.8	98.1	586.1	124.00

The amounts of plant-food gathered by the alfalfa crop in two years are equivalent in nitrogen to that contained in 3,455 pounds of nitrate of soda ; in phosphoric acid to that contained in 613 pounds of 16 per cent available bone-black superphosphate ; and in potash to the amount contained in 1,176 pounds of muriate of potash. At the prices of nitrogen, phosphoric acid and potash assumed in estimating the values of commercial fertilizers, these amounts of plant-food would cost \$124.

Fodders and feeds (pp. 114–130.)

This Station has in the past devoted a large portion of time to the study and analysis of fodders and feeds. Feeding trials have also been made both with different farm crops and with waste products largely bought to utilize the coarser materials of the farm. These trials have had for their primary purpose the determining of their proper position in the list of nutrients, at the same time testing the German feeding standards.

Chemical analyses of four hundred and sixty-one samples of fodders and feeds have been made, including nearly all the materials serviceable as food for farm animals. The results of these analyses, showing the composition of the different samples and the variations in the composition of materials of the same kind, have appeared from year to year in the reports of this Station, accompanied by such comments and explanations as were deemed necessary.

There is, however, a continual demand upon the Station from the farmers of the State for just such information as this work was intended to furnish, which indicates that the work is appreciated, but is not readily used in the form in which it is published. The Station feels warranted, therefore, in making further attempts to render this work available for all.

With this idea in mind the following tables have been arranged. The first table contains twenty-two samples, and shows the pounds per hundred and per ton of the different digestible food compounds, of the ash, and of the fertilizing elements. These samples have been selected as representing the principal feeding stuffs, and also because their percentages of digestibility can be reasonably relied upon.

As a means of comparison, as well as to show the relative value of the materials both as feed and as fertilizer, money values have been assumed. Protein and fat have been valued at $4\frac{1}{2}$ cents, and carbohydrates at nine-tenths of a cent per pound ; of the fertilizing ingredients, nitrogen has been valued at $16\frac{1}{2}$ cents, phosphoric acid at 8 cents, and potash at $4\frac{1}{4}$ cents per pound.

The actual value of these food and fertilizer constituents depends upon the degree of skill exercised in their use.

The tabulations represent average analyses secured from a relatively large number of samples ; the fodders in all cases were grown in the different counties of the State. Differences in composition are observed between those fodders grown upon soils in a good state of fertility and rich in organic matter and those grown on light and sandy soil ; in nearly every case the former are richer in fat and protein. Great differences are likely to occur also if hay, corn fodder, straw, etc., are not cut at the proper time or not gathered in good condition. The feeds, on the other hand, when properly

classified, are reasonably uniform in composition. While these averages are, therefore, trustworthy in the majority of cases, judgment must be exercised when products used are known to be either extra good or very poor, and use made of tables published on a subsequent page.

Tables of analyses of fodders and feeds.

FOOD CONSTITUENTS (DIGESTIBLE).

No. of analyses averaged.	Sample.		Dry matter.	Crude fat.	Crude protein.	Carbohydrates, including fiber.	Estimated feeding value per ton.
6	Brewers' grains	{ lbs. per hundred..	.....	1.81	5.44	16.78	.....
		{ lbs. per ton .....	.....	36.20	108.80	235.60	\$9.30
11	Clover hay	{ lbs. per hundred..	92.30	1.68	8.35	44.28	.....
		{ lbs. per ton .....	.....	33.60	167.00	885.60	14.20
7	Corn meal	{ lbs. per hundred..	87.21	3.30	6.58	65.40	.....
		{ lbs. per ton .....	.....	66.00	131.60	1,309.80	20.40
5	Cotton-seed meal.....	{ lbs. per hundred..	90.67	10.76	37.83	20.03	.....
		{ lbs. per ton .....	.....	215.20	756.60	400.60	45.50
11	Field corn-stalks	{ lbs. per hundred..	90.29	0.85	3.00	53.83	.....
		{ lbs. per ton .....	.....	17.00	60.00	1,076.60	13.00
20	Fodder corn (green)	{ lbs. per hundred..	.....	0.30	1.22	14.83	.....
		{ lbs. per ton .....	.....	6.00	24.40	296.60	4.00
	Fodder corn (dry)	{ lbs. per hundred..	.....	1.26	5.11	62.07	.....
		{ lbs. per ton .....	.....	25.20	102.20	1,241.40	16.70
7	German millet.....	{ lbs. per hundred..	92.25	0.87	3.95	45.69	.....
		{ lbs. per ton .....	.....	17.40	79.00	913.80	12.40
6	Linseed meal (old process).....	{ lbs. per hundred..	90.54	6.06	27.81	36.73	.....
		{ lbs. per ton .....	.....	121.20	556.20	734.60	36.00
2	Linseed meal (new process) ..	{ lbs. per hundred..	91.39	3.45	26.83	44.19	.....
		{ lbs. per ton .....	.....	69.00	536.60	883.80	34.20
17	Lucern (green)	{ lbs. per hundred..	.....	0.40	3.65	10.54	.....
		{ lbs. per ton .....	.....	8.00	73.00	216.80	5.40
	Lucern hay	{ lbs. per hundred..	92.30	1.46	13.33	38.48	.....
		{ lbs. per ton .....	.....	29.20	266.60	769.60	19.75
	Malt sprouts	{ lbs. per hundred..	89.52	1.12	11.85	60.84	.....
		{ lbs. per ton .....	.....	22.40	237.00	1,216.80	22.20
8	Oats (ground)	{ lbs. per hundred..	88.83	3.90	9.83	49.31	.....
		{ lbs. per ton .....	.....	78.00	196.60	986.20	20.80
7	Oat straw	{ lbs. per hundred..	91.94	0.64	1.53	40.93	.....
		{ lbs. per ton .....	.....	12.80	30.60	818.60	9.25
3	Orchard grass	{ lbs. per hundred..	93.00	0.89	2.97	47.72	.....
		{ lbs. per ton .....	.....	17.80	59.40	954.40	11.90
6	Rye straw	{ lbs. per hundred..	93.36	0.40	0.78	49.92	.....
		{ lbs. per ton .....	.....	8.00	15.60	998.40	10.00
10	Timothy hay	{ lbs. per hundred..	92.88	0.88	3.56	48.70	.....
		{ lbs. per ton .....	.....	17.60	71.20	974.00	12.60
6	Wheat bran	{ lbs. per hundred..	87.91	3.22	13.35	45.84	.....
		{ lbs. per ton .....	.....	64.40	267.00	916.80	22.70
2	Wheat chaff	{ lbs. per hundred..	93.00	0.39	1.09	34.69	.....
		{ lbs. per ton .....	.....	7.80	21.80	693.80	7.50
11	Wheat middlings.....	{ lbs. per hundred..	87.83	2.78	13.09	49.90	.....
		{ lbs. per ton .....	.....	55.60	261.80	998.00	23.00
5	Wheat straw	{ lbs. per hundred..	93.00	0.41	0.65	38.37	.....
		{ lbs. per ton .....	.....	8.20	13.00	767.40	7.81

FERTILIZER CONSTITUENTS.

No. of analyses averaged.	Sample.		Ash.	Nitrogen.	Phosphoric acid.	Potash.	Fertilizing value per ton at present prices.
6	Brewers' grains.....	{ lbs. per hundred..	1.51	0.11	0.31	0.05	.....
		{ lbs. per ton	30.20	2.20	6.20	1.00	\$0.90
11	Clover hay	{ lbs. per hundred..	6.80	1.99	0.36	1.68	.....
		{ lbs. per ton	136.00	39.80	7.20	33.60	8.60
7	Corn meal	{ lbs. per hundred..	1.41	1.45	0.62	0.39	.....
		{ lbs. per ton	28.20	29.00	12.40	7.80	6.10
5	Cotton-seed meal	{ lbs. per hundred..	7.35	6.93	3.28	1.91	.....
		{ lbs. per ton	147.00	138.60	75.60	38.20	30.50
11	Field corn stalks.....	{ lbs. per hundred..	5.98	0.94	0.26	1.02	.....
		{ lbs. per ton	119.60	18.80	5.20	20.40	4.40
20	Fodder corn (green)	{ lbs. per hundred..	1.49	0.29	0.11	0.36	.....
		{ lbs. per ton	29.80	5.80	2.20	7.20	1.40
	Fodder corn (dry)	{ lbs. per hundred..	6.24	1.21	0.46	1.51	.....
		{ lbs. per ton	124.80	24.20	9.20	30.20	6.00
7	German millet.....	{ lbs. per hundred..	6.18	1.21	0.35	1.29	.....
		{ lbs. per ton	123.60	24.20	7.00	25.80	5.70
6	Linseed meal (old process).....	{ lbs. per hundred..	5.76	5.45	2.08	1.47	.....
		{ lbs. per ton	115.20	109.00	41.60	29.40	22.60
2	Linseed meal (new process).....	{ lbs. per hundred..	6.04	5.71	2.22	1.59	.....
		{ lbs. per ton	120.80	114.20	44.40	31.80	23.75
17	Lucern (green).....	{ lbs. per hundred..	2.21	0.72	0.12	0.67	.....
		{ lbs. per ton	44.20	14.40	2.40	13.40	3.15
	Lucern hay.....	{ lbs. per hundred..	8.07	2.63	0.41	2.45	.....
		{ lbs. per ton	161.40	52.60	8.20	49.00	11.40
	Malt sprouts.....	{ lbs. per hundred..	12.48	3.97	1.46	1.65	.....
		{ lbs. per ton	249.60	79.40	29.20	33.00	16.80
8	Oats (ground)	{ lbs. per hundred..	3.37	1.86	0.77	0.59	.....
		{ lbs. per ton	67.40	37.20	15.40	11.80	7.90
7	Oat straw	{ lbs. per hundred..	4.75	0.65	0.22	1.22	.....
		{ lbs. per ton	95.00	13.00	4.40	24.40	3.50
3	Orchard grass	{ lbs. per hundred..	5.17	0.91	0.28	1.64	.....
		{ lbs. per ton	103.40	18.20	5.60	32.80	4.80
6	Rye straw	{ lbs. per hundred..	3.25	0.50	0.29	0.79	.....
		{ lbs. per ton	65.00	10.00	5.80	15.80	2.80
10	Timothy hay	{ lbs. per hundred..	4.32	1.00	0.36	1.30	.....
		{ lbs. per ton	86.40	20.00	7.20	26.00	5.00
6	Wheat bran	{ lbs. per hundred..	6.05	2.45	2.92	1.59	.....
		{ lbs. per ton	121.00	49.00	58.40	31.80	14.10
2	Wheat chaff.....	{ lbs. per hundred..	7.18	0.68	0.95	0.56	.....
		{ lbs. per ton	143.60	13.60	19.00	11.20	4.24
11	Wheat middlings.....	{ lbs. per hundred..	2.43	2.38	1.21	0.65	.....
		{ lbs. per ton	48.60	47.60	24.20	13.00	10.30
5	Wheat straw.....	{ lbs. per hundred..	3.45	0.51	0.09	0.74	.....
		{ lbs. per ton	69.00	10.20	1.80	14.80	2.50

The article also contains the classified analyses of fodders and feeds made at this Station, compared with similar analyses secured by Prof. Julius Kuhn, of Halle, Germany, and by Dr. E. H. Jenkins, of the Connecticut Experiment Station.

[As the Office of Experiment Stations is having results of analyses of American feeding stuffs collated for a separate publication, the tables given in the report are not inserted here.]

Notes on the Analytical Methods used at the Station, (pp. 131-132).

Analytical methods.—For potash determinations, Lindo's method was used with perfect satisfaction.

For phosphoric acid: The solution of phosphates was secured by the potassium chlorate and the magnesium nitrate methods.

For nitrogen: All samples free from nitrates determined by both the soda-lime and Kjeldahl methods. For determination of all forms of

nitrogen in fertilizers, the modification of Kjeldahl's method and the absolute method was used with forty-two samples, the average difference by the two methods being less than two-hundredths of one per cent.

Sorghum and sugar-making (pp. 133-162).—Experiments in growing sorghum and making sugar from its cane have been carried on in New Jersey since 1881, to encourage this industry. The State has paid bounties aggregating about \$44,000. The results have clearly proven that sorghum containing sugar in workable quantities can be successfully grown in New Jersey. The attempts to manufacture sugar were not financially successful until the year 1887. In the introduction to this article the Director says:

In that year Mr. Henry A. Hughes organized the Hughes Sugar Company and, with the assistance of the United States Department of Agriculture, built and equipped a small sugar-house, to work 15 or 20 tons of cane per day. The machinery in this house was mainly of his own invention, and included machines for topping, stripping, and shredding the cane, and for extracting the sugar by diffusion. The results of the work in 1887 were, in many respects, satisfactory, and the experience gained showed where and how many savings of time, labor, and expense could be made.

The Station has, every year from 1884, had its chemist, Dr. Neale, devote a considerable part of his time to the study of the methods pursued in the sugar-house at Rio Grande, and he has been able to render essential and important aid in arranging and balancing the new inventions.

In 1888 better results than ever before have been obtained in extracting the sugar by the smallest quantity of water, and thus saving time and expense in evaporating the diffusion juice, and the studies for economizing labor have shown where other savings can be made.

A report upon experiments made at Rio Grande during 1888, A. T. Neale, Ph. D.

The eighth annual report of this Station contains a detailed description of the Hughes sugar-house, a brief account of its machinery and a copy of its record for the season of 1887. This record strengthened the opinion that a sorghum-sugar industry could be developed in New Jersey, and led to a closer study of the conditions upon which financial success seemed to be dependent. Prominent among these conditions were the questions as to the average percentage of sugar in sorghum, the area of land available for this crop, and the size, the equipment, and the management of the sugar-house.

During the months of September and October, 1887, samples of shredded cane were drawn daily, to represent the sorghum which was used during this period in the Rio Grande factory. The results of more than sixty analyses indicated that each ton of unstripped and untopped cane contained on the average one hundred and fifteen pounds of pure sugar.

Within a radius of 1 mile from a sugar-house properly located in any good farming section of southern New Jersey, 200 acres of land suitable for sorghum can be found, year after year, without disturbing the present system of crop rotation. Such an area should yield 2,800 tons of field cane—averaging, as above stated, 115 pounds of pure sugar per ton.

The size of a factory should depend upon the length of the sugar-making season and upon the tonnage of available cane. At Rio Grande, seventy working days can be secured each fall; in order to handle 2,800 tons of field cane, therefore, the capacity of a house must be at least 40 tons per day.

Every machine needed in order to extract 90 per cent of the total sugar in normal cane has already been invented and thoroughly tested. Financial success requires,

however, that each machine shall be economic in its demands upon human labor and steam power; that it shall be constructed in such a manner that no repairs shall be necessary during the working season; that, as regards capacity, it shall neither exceed nor fall short of the amount which the plans for the house require; and that the different pieces of apparatus shall be so arranged with reference to each other that mechanical wastes of sugar shall be absolutely impossible. The equipment and arrangement of a sugar-house which can fulfill all of the above conditions is a problem which must be solved before the farmers of this State should turn their attention towards this industry.

The inducement to solve this problem can be stated as follows: A ton of field cane contains, under normal conditions, approximately, 115 pounds of pure sugar, of which 90 per cent, or 104 pounds, can be extracted by means of the diffusion process. Of the total sugar in the melada, at least 70 per cent will crystallize when the purity of the cane juice is 64 degrees. The yield from each ton of field sorghum should, therefore, be 72 pounds of pure sugar, or 83 pounds of raw sugar testing 86 per cent. The balance of the extracted sugar, viz, 32 pounds, will remain in the molasses, of which there should be, approximately, 11 gallons. Raw sugar testing 86 per cent was sold in Philadelphia, December 17, 1888, for 5 $\frac{7}{8}$ cents per pound, and raw molasses of the sorghum grade was sold for 23 cents per gallon. The present market value of the possible products from 1 ton of field sorghum amounts, therefore, to \$3; this includes 60 cents' worth of seed.

The contracts between the farmers and the sugar-house company required that all merchantable products secured from the cane should be shared equally. Four dollars, therefore, would represent the cash value to the farm of a ton of cane, which would cost approximately \$2.50 when delivered at the sugar-mill. This means \$21 profit per acre, or 30 per cent interest upon \$70 invested in farming land.

A 40-ton sugar-house can be planned to work field sorghum for approximately \$2.60 per ton. With \$4 per ton as the company's share of the products, a balance would remain of \$1.40 per ton, or \$56 per day. Seventy days' work under such conditions would leave \$3,900 in the treasury at the close of the season. The capital necessary to build and equip a house of the above size is estimated roughly at \$15,000.

It is certainly desirable that every effort should be made to improve the quality of sorghum; but it is evident that the vital problems to-day are—

- (1) To limit the waste of sugar in sugar-house manipulations to 10 per cent of the total amount present in normal cane.
- (2) To limit sugar-house expenses to \$2.60 per ton of field cane.

These problems were selected for study during the season of 1888.

Owing to financial difficulties and faults in the construction of the diffusion battery no advance was made in the solution of these problems. The details of the work performed in 1888 are given under the following heads:

- (1) The changes and improvements made in the Hughes sugar-house and in its machinery.
- (2) Record of the analyses made at Rio Grande during the season of 1888.
- (3) The tonnage of cane per acre, the farming expenses, and the yield and value of sugar products per ton of field cane.
- (4) Experiments made to secure data for comparing the modified diffusion battery in use at Rio Grande with the German diffusion battery used at Magnolia, Louisiana, and at Fort Scott, Kans.
- (5) The cost of concentrating diffusion juice with fuel-oil burners, and the effects of this treatment on the quality of the product.
- (6) Notes which may be of value in demonstrating that financial success can be secured, under present commercial conditions, with sorghum containing 9 per cent of sugar in its juice.

Inasmuch as the results of this work have been widely reported and commented on, and an abstract already published by this Department (Division of Chemistry, Bulletin No. 20), the details are not given here.

REPORT OF BIOLOGIST, JULIUS NELSON, PH. D. (pp. 163-201).—The report deals exclusively with the oyster industry of New Jersey, and consists mainly of statistics collected by the biologist since September, 1888. The details of the report are given under the following heads:

- (1) Oyster interests of New Jersey.
- (2) Some points of practical importance in the natural history of the oyster.
- (3) Extent, product, and condition of the natural beds.
- (4) Clamming grounds.
- (5) Extent and condition of the oyster-planting industry.
- (6) Means for improving the oyster-cultural industry.
- (7) Statistical summary of the oyster industry of New Jersey.

Localities.	Area of natural beds.	Native seed planted or produced, etc.	Area of planted grounds.	Oysters marketed.
	<i>Acres.</i>	<i>Bush.</i>	<i>Acres.</i>	<i>Bush.</i>
Newark Bay.....	1,000	*20,000	.....	.....
Raritan River.....	1,000	*2,000	.....	.....
Perth Amboy.....	.....	45,000	125	60,000
Keyport.....	.....	200,000	1,600	262,000
Shrewsbury.....	.....	.....	600	†100,000
Barneget.....	13,000	15,000	125	20,000
Manahawkin.....	.....	10,000	75	10,000
West Creek.....	.....	50,000	640	60,000
Tuckerton, etc.....	.....	15,000	125	30,000
Mullica River.....	4,000	.....	.....	.....
Absecon, etc.....	.....	60,000	500	60,000
Pleasantville, etc.....	.....	15,000	600	70,000
Somers Point, etc.....	.....	15,000	300	70,000
Capo May County.....	.....	10,000	300	60,000
Maurice River Cove and Delaware Bay.....	60,000	‡1,250,000	10,000	§1,250,000
Total.....	79,000	‡1,707,000	14,990	||2,052,000
Averages.....	About 20 bushels per acre, worth from \$5 to \$10.		¶ Nearly \$140 income per acre.	

Clams are produced by 100,000 acres, yielding an income of \$2 per acre. By this and the oyster industry at least 60,000 persons are supported.

* Includes only what is produced, *i. e.*, not planted in the State.

† Includes also South Shrewsbury.

‡ This estimate is below the average. It will be safe to place the yield of native oysters in the State at 2,000,000 bushels.

§ The yield for 1888 was less than two-thirds of this amount, but was exceptionally small.

|| This may be read either as bushels or as dollars.

¶ The estimate of acres of planted ground is purposely taken as too large. The income usually expected is between \$200 and \$300 per acre.

The figures in the above table are estimates from such data as could be collected from people connected with this industry. It is at present practically impossible to obtain data that can be considered accurate.

The annual income to the people along the coast can be safely placed at \$2,250,000 from both the oyster and the clam fisheries. The population of the townships bor-

dering the beds and the planting grounds, excluding all north of Perth Amboy and all sea-side resorts, is 62,389. All of these are not engaged directly in these fisheries, but they depend upon them for support, the presence of the capital, and the earnings of those who are engaged in the business.

The State receives not a cent from the land which is held by the oyster planters. It is believed that the waters of New Jersey are capable of yielding ten times as great a revenue to the people, and a corresponding revenue to the State, if the industry be placed legally upon its proper footing, by the giving up of the tide-waters to the people to hold and cultivate as any other land, and to pay the proper taxes thereon.

REPORT OF ENTOMOLOGIST, GEORGE D. HULST, M. A. (pp. 202-212).—This report contains an account of a number of the most injurious insects found in New Jersey, with remedies.

REPORT OF CHEMICAL GEOLOGIST, HORACE B. PATTON, PH. D. (pp. 213-221).—As the act of Congress making appropriation for experiment stations for the fiscal year of 1889-90 provides, "that, as far as practicable, all such stations shall devote a portion of their work to the examination and classification of the soils of their respective States and Territories, with a view to securing more extended knowledge and better developments of their agricultural capabilities," the Geological Survey of New Jersey has devoted much attention to the geology of the soils of that State. The New Jersey Station has for a number of years conducted field experiments with fertilizers in different regions and upon the different geological formations of the State. It is therefore in unusually good condition to institute such chemical, physical, and other investigations of the soils as will accord with the act of Congress and bring information of value to the agriculture of the State and the country at large. It has appointed a chemical geologist for this purpose. His report can hardly fail to be of general interest, and is in substance as follows:

ON THE INVESTIGATION OF SOILS.

As the State Experiment Station has decided to add to the work previously pursued an investigation of the soils of the State, it seems advisable at this time to indicate preliminarily and briefly the scope of soil investigation in the past, and finally some of the reasons which make it desirable to assume this undertaking.

The beginning of soil investigation.—During the first part of this century, while the applications of science were producing profound revolutions in the world's varied industries, it seems to have been the almost, if not quite, universal belief, that the soil of the earth was peculiarly and exclusively the property of the farmer. Whatever may have been, from the scientist's point of view, the desirability of a scientific encroachment on these vested prerogatives of the tiller of the soil, to the farmer, at least, such an undertaking would have appeared a useless waste of labor and time; for whatever may have been considered to be the qualifications necessary to the successful pursuit of other trades, to the mind of the cultivator of the soil of that day the only knowledge of any advantage to himself was that obtained by a little practical experience behind the plow.

It is to Liebig that the scientist, as well as the practical farmer, is indebted for the removal of this indifference to the study of soils. Exact methods in soil investigation date from the beginning of the forties, when Liebig clearly showed that the plants obtain their nourishment from the soil and the air, and that vegetation can exist only where the soil contains the ash ingredients of the plants.

Encouraged by so competent a leader as Liebig, the investigation of soils soon became a popular field of work for a constantly increasing number of chemists, especially among the Germans, his fellow-countrymen.

But though the above-quoted conclusion of Liebig was subsequently abundantly verified, it soon became apparent that mere chemical analysis does not suffice to furnish a reliable index of the fertility of a soil; that there are other conditions beyond the scope of ordinary chemical inquiry, which powerfully affect the productive capacity of a soil.

The farmer's experience had taught him that the two physical soil extremes, sand and clay, no matter how thoroughly they are manured, are neither of them fitted, the one on account of its excessive dryness, the other on account of its heaviness and the resistance which it offers to the growing rootlets, to the purposes of agriculture; whereas a loamy soil, a happy mixture of the two, is prized as possessing most of the advantageous, and few of the disadvantageous, properties of both.

Most soils, including the best, consist, physically speaking, of a relatively small amount of clayey matter, intermixed with a largely preponderating mass of sand. The latter, made up of almost pure quartz, can manifestly contain little or no plant nourishment, and its function is merely that of a skeleton, rendering the soil light and porous, and pervious to air and water.

Mechanical soil analysis.—For the purpose, therefore, of gaining an insight into the mechanical subdivision of the soil ingredients, and with the hope of thus throwing some light on one of the most potent conditions controlling the growth of crops, there was rapidly developed the so-called mechanical soil analysis—that is, the mechanical separation of the soil into several conveniently chosen grades of fineness. After the coarser grades have been removed by means of graded sieves the fine sand, together with the clay, is subdivided and separated by the process of elutriation. This process is based upon the principle that, if miscellaneous material of the same, or approximately the same, specific gravity be allowed to fall through water, the coarser particles, sinking faster, will accumulate at the bottom, the less and less coarse succeeding, while the very finest will be deposited last.

All elutriators, of which a large number have been devised, may be divided into two classes. In the first and simplest class, of which the apparatus designed by Professor Knop (Knop, *Bonitirung der Ackererde*, 2 Auf., 50, 51. See, also, "Tobacco Soils," by Dr. Moore, Tenth U. S. Census, Vol. III, pp. 872, 873) is perhaps the best representative, the material is allowed to settle a definite length of time, when the water, together with the still-suspended particles, is either decanted or drawn off. By repetitions of this process, and by varying the time of settling, the desired number of separations can be made with approximate accuracy, though at the cost of considerable time and labor.

In the second class of elutriators, which are designed to run more or less automatically, the material is carried along by a regulated current of water. By graduating the current successfully to definite, known velocities, it is possible to subdivide the fine earth into grades of the required diameters, or more exactly, of known hydraulic values.

In the United States the subject of soil investigation has been extensively studied by Professor Hilgard and Dr. T. B. Osborne.

For the purpose of mechanical soil analysis Professor Hilgard uses a "churn elutriator" (*Am. Jour. Sci.*, Oct. and Nov., 1873), in which he replaces the conical vessels with a cylindrical tube.

Dr. Osborne has devised the so-named "beaker elutriation" method (see Report of Conn. Agr. Exp. Station for 1886 and 1887). His work confirms Professor Hilgard's conclusions as to the effect of conical vessels, and shows the misleading results obtained by previously boiling

the soils "because it not only abrades and reduces the coarser sediments, but dehydrates and coagulates the true clay, and thus essentially alters the texture and grain of the soil." He also claims that the churning process may materially influence the results by unduly increasing the percentage of clay and finest silt at the expense of the coarser sediments.

Physical soil analysis.—Soon after the application of these mechanical methods to the analysis of soils, the physical properties of soils became the object of more thorough examination. Their behavior towards liquids and gases, and the influence of changes of temperature, etc., became subjects of repeated and prolonged experimentation.

To illustrate the great advantage that may accrue to the science of agriculture by these researches, the valuable and remarkable papers "On the Power of Soils to Absorb Manure," by J. Thomas Way (Jour. Royal Agr. Soc., Vol. II, 1850, pp. 313-379, and Vol. XIII, 1852), may be cited. Among many other and important conclusions which were the outcome of these papers, those of greatest value to the farmer may be summed up as follows: Soils, owing to the presence of clay, have the power to absorb from solutions the very substances that are of the most value to the crops, namely, ammonia, potash, and phosphoric acid. As far as ammonia is concerned it makes no difference which salt is used, as the salt is decomposed and the ammonia fixed in the soil. A good soil is capable of retaining sixty times as much ammonia as is necessary at any one manuring, but being once fixed it can not be readily distributed by water, hence the desirability of distributing the manure as evenly as possible. For this reason the advantage of liquid manure is apparent. On the other hand, sandy soils, containing but little clay, are not capable of fixing the valuable salts, whence the desirability of manuring such soils often and lightly, in order to prevent waste.

Whether this action of the soil in fixing these important substances, in apparent defiance of known chemical laws, is due to the chemical affinities of certain aluminosilicates, as suggested by Mr. Way in his second paper, or whether they are simply physically attached to the soil, as Liebig seems to have held (Liebig, *Die Chemie in ihrer Anwendung auf Agr. u. Physiologie*, Bd. II, S. 74), is a matter of conjecture; the value of the results obtained are of equal value to the agriculturalist in either case.

As an illustration of the important conclusions that may be legitimately drawn from a careful chemical soil analysis, we will cite a few of the analyses made under the auspices of the State geological survey and published in the report for 1879:

	Potash.	Lime.	Phosphoric acid.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1. Natural soil, woodland, Chester, Morris County	1,393	5,226	4,006
2. Virgin soil, Robert I Smith, Bloomsbury, Warren County ..	8,187	5,731	2,787
41. Natural soil, east of Whiting's, Ocean County	431	120	431

In order to interpret these figures into a language more intelligible to a farmer, let us compare them with the total amount of mineral matters taken from an acre of soil in a five years' rotation of the following crops: (1) red clover, (2) red clover, (3) Indian corn and corn stalks, (4) Irish potatoes and potato tops, (5) wheat and wheat straw, as given on page 43 of the annual report of the State geologist for the year 1878:

Pounds of potash 581
Pounds of lime 259
Pounds of phosphoric acid 179

Taking for granted, then, that the above three analyses represent all the available nourishing matter of a mineral nature that these soils contain, the third or poorest soil (No. 41) does not contain potash enough to suffice the five years' rotation of crops, as, at the above indicated rate of consumption, all the potash would be exhausted at the expiration of a little over three and one-half years. Similarly, for the same soil, the lime would last about two and one-third, and the phosphoric acid twelve years.

On the other hand, soil No. 1 would appear to contain the necessary potash for twelve years, lime for one hundred and seven, and phosphoric acid for one hundred and twelve years' cultivation. For soil No. 2 the corresponding figures are, for potash, sixty-two years; for lime, one hundred and ten years, and for phosphoric acid seventy-eight years.

It is quite manifest, from these analyses, that the farmer can expect to get from the poorest of these soils only what he puts into it in the form of fertilizers, whereas the other two, especially the soil from Bloomsbury, hold in reserve a large store of plant-food, which can only be exhausted after many years, possibly scores of years, of incessant tillage, without receiving any accessions whatever.

Prospects of soil investigation.—Considering the great amount of knowledge that has been already attained in the investigation of soils, and encouraged by the rapid progress of the last score of years, there is good reason to hope that the further pursuit of the subject will continue to yield results of the greatest importance, both to science and to agriculture.

Reasons for encouragement of soil investigation in the United States.—In a paper on the "Objects and Interpretation of Soil Analyses," published in the American Journal of Science for 1881, Professor Hilgard refers to "two chief factors that have contributed to bringing soil analyses into disrepute in Europe; one is, the fact that virgin soils are there practically non-existent, nearly all the soils analyzed having been at some time subjected to cultivation, and, concurrently to the use of manure, thus veiling their original characteristics and rendering extremely difficult, to say the least, the taking of any sample of soil that shall correctly represent the whole of a large field or district. The second is, the absence of systematic investigation of the subject since the time of the introduction of the most essential improvements in the determination of some of the chiefly important mineral soil ingredients." In the subsequent plea he makes for the continuation of soil analysis, he urges, and justly, the exceptional conditions still existing in the United States, where virgin soils that have never seen the plow are very common, and from which, if anywhere, concordant results may be expected. In his study of the soils of Mississippi, Professor Hilgard finds these expectations fully realized. "The first question arising in this particular connection," says he, referring to the interpretation of the results of soil analyses to the farmer, "is naturally, whether all soils, having what experience proves to be high percentages of plant-food when analyzed by the processes above given, show a high degree of productiveness. So far as my experience goes this question can, for virgin soils, be unqualifiedly answered in the affirmative; provided only, that improper physical conditions do not interfere with the welfare of the plant."

Virgin soils, however, are by no means confined to the West and South, but even in the Eastern States, and in particular in New Jersey, there are many regions that have never been cultivated, and where the principles laid down by Professor Hilgard for the study of the soils of the West may with great advantage be applied.

Origin of soils.—It is evident to a very casual observer that the soil, the uppermost layer of the earth, is rarely entirely independent, as to its nature, from the underlying material of the earth. In the vast majority of cases it has been derived from that underlying material by the process of weathering—that is, through the influence of heat and cold, and through the chemical activity of air and percolating water. A knowledge, therefore, of the subjacent rocks from which our soils have been derived, and of the chemical and physical forces that have first caused the disintegration of the solid rock, then gradually converted the débris into a fruitful soil, is of the first importance to the soil investigator.

It is a matter of congratulation to learn that the U. S. Geological Survey is turning its earnest attention to preparing soil maps in addition to ordinary geological maps of the districts under survey. In his report for the last fiscal year the director of the survey, Major Powell, has presented a tentative classification of soils, grouping them under two general heads, as follows :

“*Endogenous soils* are those derived from the country rocks and remaining in place.”

“*Exogenous soils* are those derived from other sources than the country rocks proper to the district where the several soils are situated.”

These two groups of soils are well represented in the State of New Jersey. North of a line running in irregular course across the State from Perth Amboy to Belvidere, the country rock is deeply buried by the glacial drift, which has been scraped together far to the north and dumped down here in promiscuous confusion. The soils in this part of the State naturally partake of the heterogeneous nature of the drift from which they are derived.

To the south of the afore-mentioned line the soils belong mostly to the “endogenous soils,” and here is where the most important results are to be looked for. In this respect New Jersey has a great advantage over the more northerly situated drift-covered States.

The geological survey of the State of New Jersey has already made a good start in the investigation of the soils of the State. The annual report of the State geologist for the year 1878 contains a “preliminary description and classification of the soils of New Jersey,” in which they are divided, according to their origin, into the following kinds, viz :

Granitic soils.	Clay-district soils.
Limestone soils.	Drift soils.
Slate soils.	Marl-region soils.
Red sandstone and shale soils.	Tertiary soils.
Trap-rock soils.	Alluvial soils.

The geological formations of the southern and eastern portion of the State, which consist of sands, gravels, and clays, are themselves the débris swept together from pre-existing rock-masses, and have already undergone, either before or during their transportation, that disintegration and decay which must necessarily precede the formation of soil. In order, therefore, to study the whole process of soil formation, we must seek the more northern portion of the driftless area, where the solid country-rock comes to the surface. Such soils are the red sandstone, shale, trap-rock, and the granitic soils, which are homogeneous in texture and composition over extensive areas. Here, too, we may find the condition, indicated by Hilgard, of successful soil analysis fulfilled, viz, a virgin soil, untouched by the plow and unacquainted with manure.

As no universally acceptable classification of soils has as yet been proposed by soil investigators, the above-given natural and simple classification, chosen with special reference to the soils of this State, presents a strong claim for recognition, and will, for the present at least, with such amplifications as future investigations shall make necessary, be adopted by the State Agricultural Experiment Station.

APPENDIX (pp. 233, 234).—The appendix contains the acts of the legislature relating to the Station and to fertilizer control, directions for sampling fertilizers, the order of station work, and the following catalogue of bulletins :

Catalogue of Bulletins issued by the New Jersey Agricultural Experiment Station from its organization, in 1880, to December 31, 1888.

No.	Title.	Date.
1	Suggestions in Regard to the Cranberry Rot and its Cure	May 17, 1880
2	Raspberry Disease and Suggestions for Overcoming it	June 4, 1880
3	Analyses of Land Plaster	June 25, 1880
4	Analyses of Guanos, Superphosphates, and Special Manures	July 3, 1880
5	Analyses of Bone Dust	Aug. 9, 1880
6	Analyses of Various Fertilizers	Aug. 16, 1880
7	Analyses of Various Fertilizers	Aug. 28, 1880
8	Analyses of Various Fertilizers	Sept. 6, 1880
9	Analyses of Various Fertilizers	Oct. 16, 1880
10	Rational System of Feeding Milch Cows	Jan. 15, 1881
11	Ensilage	Mar. 7, 1881
12	Valuation of Fertilizers	Mar. 30, 1881
13	Land Plaster and Ground Bone	May 5, 1881
14	Clover-Seed Midge	May 26, 1881
15	Commercial Fertilizers; their Composition and Valuations	July 18, 1881
16	Commercial Fertilizers	Sept. 20, 1881
17	Commercial Fertilizers	Nov. 12, 1881
18	Sorghum Sugar-Cane	Dec. 20, 1881
19	Green Fodder Corn; Dried Fodder Corn; Ensilage	Feb. 20, 1882
20	Valuation of Fertilizers	Mar. 30, 1882
21	Chemical Fertilizers (Incomplete)	July 10, 1882
22	Commercial Fertilizers (Complete and Incomplete)	July 28, 1882
23	Commercial Fertilizers	Oct. 10, 1882
24	Sorghum; Feeding Experiments with Sorghum Seed	Nov. 25, 1882
25	Sorghum and Sugar; Experiments and Investigations of 1882	Dec. 8, 1882
26	Field Experiments	Jan. 4, 1883
27	Prices of Nitrogen, Phosphoric Acid and Potash, and Analyses of Incomplete Fertilizers	Apr. 21, 1883
28	Analyses and Valuations of Complete Manures and Special Fertilizers	July 2, 1883
29	Analyses and Valuations of Nitrogenous Superphosphates, Ground Bones, Plain Superphosphates, Poudrettes, and Miscellaneous Fertilizers	Aug. 2, 1883
30	Results of Field and Laboratory Experiments with Sorghum, for the Season of 1883	Nov. 16, 1883
31	Nitrate of Soda or Chili Saltpeter as a Top Dressing for Wheat	Dec. 22, 1883
32	Prices of Nitrogen, Phosphoric Acid, and Potash	Mar. 28, 1884
33	Analyses and Valuations of Complete Fertilizers	Aug. 2, 1884
34	Analyses and Valuations of Incomplete Fertilizers	Sept. 27, 1884
35	Meaning of Stations' Valuations, Schedule of Trade Values for 1885, Chemical Composition, Retail Prices, and Guaranteed Analyses of Fertilizer Supplies	July 1, 1885
36	Analyses and Valuations of Complete Fertilizers	Oct. 2, 1885
37	Miscellaneous Fertilizers	Dec. 7, 1885
38	The Rio Grande Sorghum Sugar Works	Dec. 21, 1885
39	Meaning of Stations' Valuations, Schedule of Trade Values for 1886	Mar. 19, 1886
40	Analyses and Valuations of Complete Fertilizers	Oct. 16, 1886
41	The Extraction of Sugar from Sorghum at Rio Grande, Cape May County, N. J.	Jan. 22, 1887
42	Analyses and Valuations of Complete Fertilizers	Sept. 3, 1887
43	Analyses and Valuations of Complete Fertilizers of Ground Bones and of Miscellaneous Material	Dec. 31, 1887
44	Sorghum and Sugar-making; a Report upon Experiments made at Rio Grande During the Season of 1887	Mar. 8, 1888
45	Prices of Nitrogen, Phosphoric Acid, and Potash	Mar. 10, 1888
46	Insect Pests and the Means for Destroying Them	May 23, 1888
47	Analyses and Valuations of Incomplete Fertilizers	June 23, 1888
48	Analyses and Valuations of Complete Fertilizers	Aug. 7, 1888
49	Analyses and Valuations of Complete Fertilizers, Ground Bone, and Miscellaneous Samples of other Fertilizing Materials	Nov. 10, 1888
50	Insects Injurious to the Cabbage and the Best Means of Preventing Their Ravages	Dec. 5, 1888
51	Sorghum and Sugar-making; a Report Upon Experiments Made at Rio Grande During the Season of 1888	Dec. 31, 1888

NEW YORK.

New York Agricultural Experiment Station.

Location, Geneva.

Director, Peter Collier, Ph. D.

SEVENTH ANNUAL REPORT FOR THE YEAR 1888.

REPORT OF EXECUTIVE COMMITTEE OF THE BOARD OF CONTROL
(pp. V-VII).

REPORT OF DIRECTOR (pp. 3-58).—The report urges the necessity of larger appropriations, and gives reasons to show the desirability of increasing the means for the support of the Station. It also contains statistics of the agriculture of New York, a digest of fertilizer laws in several of the States, the full text of the bill for fertilizer control introduced in the New York legislature in March, 1888, and of a substitute for this bill framed to meet the objections of the manufacturers of fertilizers; plans for the proposed investigations of the breeds of dairy cattle; a plea for the establishment of branch stations; statistics of the poultry industry to show the desirability of the experiments in this line begun at the Station; an account of the arrangements made at the new barn for the preservation of barn-yard manure; plans for a permanent exhibition of agricultural tools and implements; brief comments on the work of the Station; statements regarding sorghum syrup; reference to the value of plat experiments; the usefulness of the Station and the hearty sympathy between it and the farmers of the State; and, finally, a list of newspapers and other periodicals given by the publishers, and of a large number of other gifts to the Station.

During 1888 the Station has published six bulletins, in which the following subjects have been discussed and the results of the work of the Station set forth:

Bulletin No. 10—August, 1888:

- (1) Influence of fertilizers on the chemical composition of plants.
- (2) Analysis of feeding stuffs.
- (3) Feeding and digestion experiments.

Bulletin No. 11—September, 1888:

- (1) Experiments in cultivation.
- (2) Experiments in root growth.
- (3) Experiments with fertilizers.
- (4) Experiments with insecticides.
- (5) Experiments with fungicides.
- (6) Experiments with the potato.
- (7) Experiments with sorghum.

Bulletin No. 12—September, 1888:

- (1) Digest of the fertilizer laws in several States.
- (2) Statistics of fertilizers.
- (3) The Maynard bill.

Bulletin No. 13—September, 1888:

- Farm and field experiments:
- Condition of the farm.
 - Rotation of crops.

Bulletin No. 12.—September, 1888.

Field experiments on the farm, 1888:

Oats, corn, grass.

Discussion of results.

Forage.

To the farmers of New York.

Experimental plats:

Grass plats.

Fertilizer experiments on corn, on potatoes.

Forage experiments begun on plats with corn, with sorghum.

Branch experiment stations.

Bulletin No. 14—October, 1888:

Chemical composition of some feeding stuffs:

(1) Defining of terms.

(2) Grasses, clovers, and forage crops.

(3) Grasses and by-products.

(4) Grasses of New York.

Bulletin No. 15—November, 1888:

Methods adopted for the systematic testing of new fruits.

A circular to the originators or proprietors of new fruits.

A list of fruits now under trial at the Station.

REPORT OF FIRST ASSISTANT, W. P. WHEELER (pp. 59–85).

Poultry experiments (pp. 59–71).—Experiments with 16 fowls were made to determine—

The approximate amount of food required for a fowl.

The average weight of eggs and loss of weight in keeping.

The difference in the composition of eggs in regard to proportion of the principal proximate constituents, and whether any difference is due to influence of food or of breed.

The specific gravity of eggs—of fresh eggs and those kept for a time under the ordinary conditions.

Weights and analyses of food, and of the shell, whites and yolks of the eggs and of the whole eggs are stated in detail. The results of the experiments give the following indications:

That the proportion of food consumed by hens of smaller breeds to that consumed by those of the larger is very much greater, while both are laying, than while they are not.

That different food influences not only the number of eggs produced, but also their chemical composition.

That breed, as indicated in the color of the eggshell, influences the per cent of water in the egg.

That the hen is able to obtain from inorganic material a supply of lime for the formation of the eggshell.

That eggs gradually lose weight when exposed to the air.

That the specific gravity of fresh eggs is not constant. That the limits of variations in eggs, from hens not used for breeding, are about 1.072 and 1.104. That the specific gravity diminishes in proportion to the time the egg is kept exposed to the air.

As soon as buildings and pens are available it is intended to make experiments in feeding pullets, cockerels, and capons, to secure data regarding the cost of feeding, value of products obtained, and the best rations for egg and meat production.

Sorghum (pp. 71–84).—The report contains the details of field experiments with a large number of varieties of sorghum; the results of anal-

yses of the juice of the cane of different varieties and of corn-stalks, and the results of experiments with fertilizers.

REPORT OF HORTICULTURIST, E. S. GOFF (pp. 86-198).—The report contains a list of 149 varieties of fruits added to those previously grown at the Station; notes on bearing varieties, and accounts of tests of the vegetable novelties, the word “novelties” being used in the seedman’s sense.

The Station Arboretum (pp. 140-144).—A list of trees thus far planted includes 103 deciduous trees and 19 evergreen; total, 122.

Experiments with Insecticides (pp. 144-152).

1. For the codling moth. In a limited trial Paris green was more effectual than “Zoektein poison” or London purple on apple trees.

2. With potassium sulphide.

(a) For the currant worm; the worms were not destroyed, but driven away.

(b) For the codling moth; the result was negative.

(c) For the cabbage maggot; the number of maggots were not diminished.

3. For the cabbage maggot. A solution of common salt, 4 ounces to the gallon; McDougall’s sheep dip diluted with five parts of water; the “Zoektein poison,” an ounce to 5 gallons; and pure kerosene. The first produced no visible effect; the second apparently failed to injure the insects, but was fatal to the plants; the third and fourth were fatal to both.

4. Experiments with kerosene.

Kerosene, used in its pure state, was not injurious to the foliage of some plants, as the coleus and rose, while it was fatal to that of others, as the tomato and potato.

Kerosene may be successfully atomized with water by means of a simple apparatus. Its value as an insecticide, when applied in this way, was not definitely settled.

5. The bean plant as a repellant for the striped cucumber beetle. The results were inconclusive.

6. A trial of hose nozzles of different patterns.

7. Experiments with home-grown pyrethrum. Seeds of *Pyrethrum roseum*, the plant from which the so-called Persian or Dalmatian insect powder is manufactured, were successfully grown, and the plants found to possess poisonous properties.

Experiments with fungicides (pp. 153-157).

(1) Potassium sulphide for the gooseberry mildew (*Sphaerotheca mors-uvæ*, B. and C.)

The substance was applied in solution at the rate of one-half and one-fourth ounces to the gallon, respectively, commencing May 3, or as soon as the leaves had begun to expand, and the application was repeated after every hard rain until July 24, nine sprayings having been made in all. The treatment proved beneficial, but after spraying had been discontinued, the mildew increased on the treated plants, showing that the application must be continued through the growing season.

For results secured with this substance by Dr. Arthur in 1887, see Report of New York Agricultural Experiment Station, 1887, pp. 348-352.

2. Soda hyposulphite contrasted with potassium sulphide and calcium sulphide for the apple scab (*Fusicladium dendriticum*, Fckl.).

The results of these tests appear to warrant the following conclusions :

First. That soda hyposulphite and potassium sulphide, as applied, proved beneficial in preventing injury from the fungus. This conclusion is strengthened by the results secured in previous experiments already cited.

Second. The tests do not prove that the greater amount of sulphur added in the potassium sulphide, as compared with the soda hyposulphite, rendered this substance the more effectual, though there are indications in this direction.

Third. That calcium sulphide is of little or no value for the purpose used.

Fourth. That while further experiments are needed to furnish data from which we may compute the actual benefits conferred by the treatments, the indications are that the good accomplished was sufficient to warrant the slight cost of the materials in the case of orchardists who spray their trees for the codling moth.

For reports on former experiments with soda hyposulphite, see Reports of New York Agricultural Experiment Station, 1885, pp. 231, 232; 1886, pp. 177, 178; 1887, pp. 99-101.

THE POTATO—A TEST OF VARIETIES AND REPORT OF EXPERIMENTS (pp. 158-171).

(1) *A test of varieties.*—This included forty-nine of the varieties grown at the Station in 1887, and forty-eight varieties of seedlings not before tested.

(2) *Other experiments.*—The general character of these experiments may be seen from the following conclusions drawn from them :

Little or nothing was gained by using cut potatoes for seed over whole tubers of the same weight.

Seed tubers badly sprouted yielded about $8\frac{1}{2}$ per cent less than unsprouted ones.

The earliness of the crop was not influenced by exposing the tubers to light and warmth before planting.

The yield was materially reduced by removing the seed end of the planted tubers.

Fertilizer placed below the seed may be slightly preferable to fertilizer placed above it. The fact was not clearly established.

The more rapid consumption of the seed tuber on rich than on poor soil is probably due to a more abundant supply of moisture.

THE INFLUENCE OF THE DEPTH OF TILLAGE UPON THE DEPTH OF ROOTS (OF CORN) (pp. 171-173).

With the hope of throwing light upon this question, five small plats were prepared on May 26 in the following manner :

No. 1 was worked $2\frac{1}{2}$ feet deep; No. 2, 2 feet; No. 3, $1\frac{1}{2}$ feet; No. 4, 1 foot; and No. 5, 6 inches deep. In working the plats the surface soil and subsoil were well mixed, so that the soil was left nearly uniform to the depth worked. The plats were then planted with Waushakum corn in rows 3 feet apart both ways.

On September 12 the roots of sample plants on all of the plats were washed out and examined. Although some roots on all reached to the depth of two and a half feet, a larger proportion reached to that depth on the deeply-worked than on the shallow-worked plats. The proportion of shallow roots, on the other hand, was greatest on the shallow-worked plats. On the deeply-worked plats the horizontal roots were very few. The roots appeared to diverge as they extended downward, reaching their greatest extent many inches below the surface, while in the shallow-worked plats many roots grew nearly horizontal, so that the roots on these plats reached their greatest extent but a very few inches below the surface.

The ground occupied by the roots might be represented in the deeply-worked plats by a short cone buried just beneath the surface, in its upright position, while in the shallow-worked plats the cone would need be inverted.

The differences noted in the root growth correspond well with the observations upon the growth of the plants made during the summer. During June and the early part of July, before the soil had become very dry, the corn grew most rapidly on the shallow-worked plats. In August, however, during a period of severe drought, the plants on the deeper-worked soil overtook and surpassed the others. The rich green foliage and vigorous appearance of these plants presented a striking contrast with the rolled and withering leaves of the plants on the shallow-worked soil. Toward the end of summer a regular gradation in the height of the plants was noticeable, as well as in their stage of maturity, the tallest and least mature plants being those on the deepest-worked plat. All, however, ripened before frost.

The yield of the different plats, which may have some interest, is given below. It appears that the deepest and most shallow tillage gave the largest yield of corn, while the shallow-tilled plats gave the smallest yield of stalks:

Plat.	Stalks.	Ears.	Weight of ears.	Weight of stalks.
			<i>Pounds.</i>	<i>Pounds.</i>
Worked $2\frac{1}{2}$ feet deep.....	24	28	10	11 $\frac{3}{4}$
Worked 2 feet deep.....	24	23	7 $\frac{3}{4}$	10
Worked $1\frac{1}{2}$ feet deep.....	23	23	8 $\frac{1}{2}$	10 $\frac{1}{4}$
Worked 1 foot deep.....	24	24	7	7
Worked 6 inches deep.....	24	26	9 $\frac{2}{8}$	8

From this experiment and the one cited from our report for 1887 we are justified in believing that in soil like that of the Station the depth of corn roots is influenced to some extent by the depth of tillage. The indications are that the distribution of roots depends rather more upon the presence of a proper supply of oxygen in the soil than upon a given degree of warmth. The deep tillage doubtless produced and favored the maintenance of a thorough aeration of the soil to the depth worked.

EXPERIMENTS IN THE CULTIVATION OF CORN (pp. 173-178).

The experiments were of three kinds:

(1) *To determine the effects of root mutilation, considered alone.*

Object of the experiment: To ascertain the effects of cutting the roots of young corn plants, as independent from the effects of stirring the soil—an experiment of 1887 repeated.

Main plats D 8 and G 14 were planted with Waushakum corn on May 22. Three kernels were placed in each hill—the hills 2 feet apart, in rows 4 feet apart. The soil was rather poor. It had been well prepared, but no fertilizer was applied. On June 9, the first and each alternate row of each plat were root-pruned, by inserting a lawn-edger to the depth of 3 inches on the four sides of the hill, keeping 4 to 8 inches distant from the plants. The tool was used in such a way as to disturb the soil as little as possible, the aim being to cut the roots to the extent that is accomplished by thorough cultivation, and to do nothing else. The tallest plants at this time were about 5 inches in height. The soil was rather dry, but nearly half an inch of rain fell during the succeeding week.

On June 25 the root-pruning was repeated in the same manner as before. The plants were at this time about 10 inches tall, without raising up the leaves. The ground was not dry, as it was during a showery period, and very copious rains fell within the next three days. The conditions were extremely favorable, therefore, for the plants to recover from the effects of the root-pruning. The weeds were kept down during the season either by pulling them by hand or by cutting them with the scuffle-hoe, the latter penetrating the ground only about half an inch. It appears, therefore, that, counting 80 pounds of the freshly-husked corn as a shelled bushel,

the rows not root-pruned yielded at the rate of 9 bushels and 42½ pounds of shelled corn and 1,020 pounds of stalks per acre more than the root-pruned rows.

We may fairly infer from the results of this experiment, taken in connection with those of the one cited from our last report, that only harm results from mutilating the roots of young corn plants.

(2) *Cultivation with respect to root mutilation.*

Object of the experiment: To ascertain if that cultivation which secures the most thorough stirring of the soil with the least possible injury to the roots is not most conducive to the crop.

In this experiment three methods of treatment were compared, viz: No cultivation, ordinary cultivation, and what I will term ideal cultivation. In the first, the weeds were to be kept down by hand or with the scuffle-hoe, but no further stirring of the soil permitted; in the second, the spaces between the rows were to be traversed twice in a place and at two different times with the ordinary corn-cultivator in ordinary condition; that is to say, the cultivator not to be of the latest improved style nor in the best condition; in the third the soil to be stirred thoroughly to the depth of 5 or 6 inches in the parts of the spaces not occupied by the roots, but to the depth of only 1 inch where the roots were present. In the last method the shallow cultivation was to be accomplished by the garden rake, and the deep by means of the one-horse plow. At the first cultivation the plow was to be passed four times through each space, keeping at least 8 inches from the hills; at the last it was to be passed only twice through each space, keeping carefully at the center.

The experiment was carried out as planned. It occupied twelve plats of one-twentieth acre each. As in the preceding experiment, individual rows were compared rather than individual plats.

The variations in duplicate plats were in some cases considerable. On the average those receiving no cultivation yielded the least and those with ideal cultivation the most; but the differences were not remarkably great, and "the results were quite inconclusive."

(3) *To determine the amount of root injury accomplished by ordinary cultivation.*

In order to ascertain how much the corn roots were really injured by the "ordinary" cultivation in the experiment just described a special examination was made on July 3. The cultivator used was one having an iron frame, with five reversible teeth, which were much worn. The rows in which the test was made were 3½ feet apart, and the cultivator teeth were so set that the width cultivated was 25 inches. The cultivator had been passed but once in a place, which left a space of about 17 inches between the centers of each two rows nearly or quite undisturbed by the cultivator teeth.

The examination was made by carefully washing away, with a stream of water delivered through a hose, the soil loosened by the cultivator. On the whole, the injury done to the roots was less than I had suspected. Still the number of roots broken was considerable. Opposite one hill containing two stalks of corn twenty-two broken roots and fibers were counted. The largest of these, however, scarcely exceeded a cambric needle in diameter. In another place twenty-five broken roots and fibers were counted opposite to a hill containing but a single plant. The bottom of the track of the cultivator, when washed clean of the loose soil, revealed in some places many broken roots and fibers; in others, none.

The cultivator teeth appeared to enter the soil about 3 inches.

CONCLUSIONS.

The first of these experiments confirms the results of last year, and shows clearly that needless root cutting is injurious.

The second experiment failed to clearly determine the method of cultivation that is most conducive to crop.

The examination with respect to the injury to the roots affected by cultivation shows that even a cultivator in poor condition run once in a place cuts quite a large number of roots.

THE INFLUENCE OF THOROUGH AS CONTRASTED WITH SLACK PREPARATION OF SOIL (pp. 178-180).

Fourteen one-twentieth acre plats were plowed uniformly. Plat 2 was harrowed once, plat 3 twice, and plat 4 three times; so on up to plat 7, which was harrowed six times. Then the order was reversed so that plat 8 was harrowed six times; plat 9 five times; plat 10 four times; and so on to plat 14, which, like plat 1, was not harrowed. All the plats were sown with White Russian oats May 23. The crop was cut August 20 and 21.

The yield of straw from the plats corresponded to some extent with the amount of labor expended in harrowing; the yield of grain, however, did not. This experiment is to be continued through a series of years in order to eliminate the influence of dissimilar treatment of the land in the past.

INVESTIGATIONS IN SOIL PHYSICS (pp. 180-198).

(1) *Influence of treatment upon soil moisture.*

(a) To ascertain how far the amounts of moisture in the portion of the soil occupied by the roots of crops may be influenced by treatment aside from artificial watering.

(b) To ascertain what depth of surface tillage retains the greatest amount of soil moisture.

(c) To compare the effects of mulching with those of tillage in retaining soil moisture.

Main plat G 9, containing one-twentieth of an acre, of which the dimensions were 33 by 66 feet, was divided into ten plats of equal size, and these were grouped into two series of five plats each. The arrangement of these plats, as well as the treatment given them, is shown in the accompanying diagram:

No. 1. Surface neither mulched nor tilled. A.	No. 2. Surface stirred one-half inch deep. B.	No. 3. Surface stirred 2 inches deep. C.	No. 4. Surface stirred 4 inches deep. D.	No. 5. Surface mulched with short oats straw 1 inch deep. E.
No. 6. Surface mulched with short oats straw 1 inch deep. E.	No. 7. Surface stirred 4 inches deep. D.	No. 8. Surface stirred 2 inches deep. C.	No. 9. Surface stirred one-half inch deep. B.	No. 10. Surface neither mulched nor tilled. A.

As appears, plats 6 to 10 inclusive are duplicates of 1 to 5, with the exception that their order is reversed. This was done in order that each pair of duplicates might represent, as nearly as possible, an average of the whole main plat. The soil of this main plat is, for the first 9 or 10 inches, a clay loam, rather light in texture for the station farm, but containing sufficient clay to make it bake somewhat in dry weather.

Below this it is a very tenacious clay, generally of a light yellow color, but in spots inclining to bluish. The soil to the depth of a foot is nearly free from large stones, but contains on the average about 4 per cent by weight of fine gravel that will not pass through a sieve of ten meshes to the inch.

The tillage on plats 2 to 4 and 7 to 9 inclusive was repeated after every rain sufficient to puddle the surface, as soon as the soil was dry enough to work. On plats 2 and 9 the garden rake only was used. On the other tilled plats the soil was thoroughly loosened with the spading fork to the required depth, after which the surface was made fine and level with the rake. Sometimes after slight rains the surface of all was raked over without using the fork. The weeds were pulled from the other plats as they required it.

Once each week, commencing May 15 and ending October 3, a sample of soil was taken to the depth of 1 foot, for drying, from each of the ten plats. The samples from each pair of duplicate plats were placed in a fruit jar as they were drawn. The jars, which were sealed as they received the sample, to prevent evaporation, were then carried to the laboratory, where the soils, after being weighed, were exposed in a drying oven surrounded by water until they ceased to lose weight, after which each sample was washed through a sieve of ten meshes to the inch and the gravel and other matters that would not pass the sieve dried, and their weights deducted from that of the fresh and dried sample. The per cent of moisture was then computed by dividing the loss of weight in drying by the net weight of the fresh sample.

With very few exceptions the plats neither mulched nor stirred contained the least moisture, while the moisture content increased regularly with the depth of the stirring and was greatest in the mulched plats.

On the average, this gradation was uniform and marked.

The influence of surface treatment assumes its chief importance in time of drought. In periods of abundant rain-fall it matters little to the farmer whether soil stirred one-half inch or 4 inches deep contains the more moisture. But when his crops are suffering from a dearth of water he would gladly know how he may best mitigate the effects of the drought.

If we observe the average moisture content of all the plats during the different weeks, as given in the right-hand column of the table, it appears that the four dates showing the lowest percentages were June 19, July 31, August 8, and September 4. During the week preceding each of these dates, then, if at all, the crops must have been suffering from drought.

In order to avoid needless repetition of words, the plats will be designated by the letters applied to them at the head of the columns in the table. Averaging the moisture percentages of the different plats for the four dates above mentioned, we have for A 14.55, B 15.625, C 15.925, D 16.575, and E 18.45.

If now we compute the excess of moisture in the other plats over A, we find that the per cent is for B 1.075, C 1.375, D 2.025, and E 3.9, from which it appears that keeping the surface stirred one-half inch deep retained 1.075 per cent of water that would otherwise have evaporated; that keeping it stirred 2 inches deep retained 1.375 per cent, 4 inches deep 2.025 per cent, and keeping it mulched 1 inch deep retained 3.9 per cent of water that would otherwise have been lost by evaporation. These differences may at first thought seem slight, but when we recall that the percentages are calculated upon the weight of the soil itself their significance more readily appears, as computations given later will show.

On September 22, an exact cubic foot of soil was taken up on opposite sides of the main plat devoted to this experiment. By drying generous samples from these measured bulks of earth, it was ascertained that the dry weight of a cubic foot of the soil under experiment was approximately 89.7 pounds. Calculating on this basis, and reducing the water contents to depth inches, as we measure rain-fall, it appears that the average amounts of water contained in each cubic foot of the different plats during the four driest weeks of the summer was for A 2.797 inches, B 3.096 inches, C 3.170

inches. D 3.275 inches, and E 3.72 inches; from which it appears that the excess of the other plats over A was for B .299 inch, C .3737 inch, D .478 inch, and E .923 inch.

Expressing these excesses in cubic inches and in liquid measure, to make them more intelligible, it appears that the excess for each cubic foot of soil was in the case of:

B. 43.056 cubic inches, or very nearly $1\frac{1}{2}$ pints.

C. 53.813 cubic inches, or nearly 1 quart.

D. 68.832 cubic inches, or more than 1 quart.

E. 132.912 cubic inches, or more than 2 quarts.

Expressing these excesses in barrels per acre, the number appears in the case of B 258 barrels, C 322 barrels, D 412 barrels, and E 799 barrels.

These figures clearly show that the amount of water retained in the soil in dry weather, by even a very shallow stirring of the surface, is by no means inconsiderable. It should be remembered that they do not represent the total amounts of water thus retained. That is to say the experiment does not show simply that B lost 258 barrels of water per acre less than A during the four weeks under consideration. It shows rather that as the average of four observations made during the four driest periods of the summer the soil of B was found to contain, incorporated within itself and available to plants, had plants been growing within reach of it, 258 barrels of water per acre more than that of A, while the other plats contained larger amounts than this. We may infer, therefore, that this excess of water was maintained throughout the periods of drought despite the losses from evaporation.

The figures also show clearly that the amount of water retained by the stirring of the surface increased with the depth of the stirring, but not in proportion to its depth. It would appear that the first half inch of stirring retained more water than any succeeding one. This would indicate that there is a clearly defined limit to the depth of profitable cultivation. So long as the benefit to the crop through the conservation of moisture is greater than the injury accruing from root laceration the cultivation is profitable; beyond this it may become unprofitable.

The influence of the mulch in retaining water in the soil is especially noticeable. The mulch used in this experiment was of fine oat straw that had served during the preceding winter in covering strawberries. Its depth did not exceed 1 inch after it had become packed a little by the rains, and it was not renewed during the season. It appears, however, that during the dry weather its efficacy in retaining water was almost double that of the deepest soil stirring used in this experiment, a fact which emphasizes the great value of mulching in its proper place.

Conclusions.—The results of this experiment warrant the following conclusions for the soil upon which it was made:

(1) That keeping the surface of the soil stirred, if only to the depth of half an inch, increases the water content of the first 12 inches to a very appreciable degree.

(2) That the deeper the tillage, at least up to 4 inches, the greater is the increase in water content.

(3) That the rate of increase diminishes as the depth increases.

(4) That a slight mulch exerts a far greater influence in retaining water than tillage 4 inches deep.

(2) *Details of the construction of new lysimeters.*

In the station report for 1887, pp. 113, 114, is briefly described a new lysimeter, devised by Dr. Babcock and myself (Mr. Goff) which is believed to possess some important advantages over those in use at other experiment stations.

During the past season, four lysimeters have been constructed at the Station on the new plan.

The new feature consists chiefly in supplying an artificial water table at the bottom of the column of soil, in order to furnish conditions more like those in the open ground. This water table is so arranged, that, while it is kept at a constant height, it does not interfere with the measurement of the percolation, and facilitates the measurement of the evaporation.

The article contains the details of the construction of the new lysimeters, and an illustration showing their peculiar features.

(3) *The progressive movement of soil water during percolation.*

These experiments have gone so far that the results seem to warrant the belief that a nearly complete displacement of the water contained in a sample of saturated soil [sand or emery flour] takes place, when a quantity of water is added at the surface equal to that already contained by the sample, and that diffusion takes place very slowly within the soil.

(4) *Experiments on capillary action in soils—(a) The height to which water rises by capillary action in different soils and its rate of progress.*—This is a continuation of an investigation with an apparatus described in the report for 1887, pages 103 and 104. The results are as yet incomplete.

(b) *The influence of matters in solution upon the rate of capillary flow.*—This is also a continuation of work reported in 1887.

(5) *The condensation of water at the surface of the soil during cold nights in spring.*

Every gardener knows that his partially dry surface soil is rendered temporarily wetter by freezing and thawing. It often happens in early spring that the soil is in excellent condition for planting at night, when on the following morning, after a clear, cold night, in which the surface freezes somewhat, it is so wet and sticky on thawing out that work upon it has to be deferred. In order to ascertain if the amount of this condensation is as great as it appears to be, two samples of soil were taken from the surface of a garden bed at 6 p. m. on April 23, and two others on the following morning. These were dried, from which it appeared that those taken at night contained on the average 7.57 per cent of water, while those taken in the morning contained 10.06 per cent. The samples were taken to the depth of about three-fourths of an inch, and the figures indicate that, to at least this depth, the soil gained in moisture content 2.49 per cent during the night. It appears, therefore, that the amount of water thus condensed is really small. If we assume that the soil increased at the same rate to the depth of 2 inches, the increase would only amount to about one-fortieth of an inch of rain.

(6) *The height of water in wells.*—The height of water in a well at different times was compared with records of rain-fall and the results shown in tabular form and in a graphic diagram. The table is given below :

Date.	1887.			1888.		
	Distance to water.		Rain-fall of preceding month.	Distance to water.		Rain-fall of preceding month.
	<i>Ft.</i>	<i>In.</i>	<i>In.</i>	<i>Ft.</i>	<i>In.</i>	<i>In.</i>
December 1 (1886 and 1887).....	13	2.	3.48	16	9.	1.58
January 1.....	6	4.	1.24	17	3.5	1.34
February 1.....	5	8.	.18	15	3.25	.78
March 1.....	4	10.25	2.97	9	11.75	1.04
April 1.....	5	.75	.48	5	1.75	1.43
May 1.....	4	2.25	1.37	4	8.	3.09
June 1.....	6	10.	.46	6	2.75	2.79
July 1.....	9	2.	2.01	7	10.25	3.88
August 1.....	10	5.75	6.37	9	2.5	.99
September 1.....	11	3.	3.03	11	7.5	4.02
October 1.....	13	4.5	.75	13	9.25	2.73
November 1.....	15	4.5	1.74	14	4.	3.46

The observations upon the depth of the water table, as indicated by the height of water in an abandoned well near the station buildings, which were commenced in December, 1886, have been continued daily throughout the past year. The results are of considerable interest, as they indicate that the depth of the water table is influenced far more by season than by the amount of rain-fall.

Although the record is much shorter than is desirable for the purpose of forming conclusions, two facts are strikingly brought out:

First. Fluctuations in the precipitation from month to month did not much affect the height of the water table. The very light precipitation of January, 1887, did not stop the rise of the water table, nor did the extremely large rain-fall of July of the same year cause the water table to stop falling.

Second. The rapid rise in the water table from January 7 to April 1, 1888, was not due to large precipitation during this time, nor was the fall from May 7 to November 1 of the same year due to small precipitation.

These facts suggest that a study of the relation of the height of the water table to the amount of rain-fall may develop some interesting, if not valuable, knowledge.

(7) *The soil hygrometer*.—For description and illustrations of this soil hygrometer see Reports of New York Agricultural Experiment Station for 1886, p. 182; 1887, p. 11.

The experiments of the past season added strength to the probability that the principle adopted is capable of furnishing an accurate record of the fluctuations in the moisture of the soil.

INDEX TO THE REPORTS OF THE HORTICULTURIST AND ASSISTANT HORTICULTURIST FOR THE YEARS 1882-1887, inclusive (pp. 199-223).

REPORT OF ASSISTANT HORTICULTURIST, M. H. BECKWITH (pp. 224-233).

(1). *Study on the potato scab* (pp. 224-227).

(a). Experiment to determine whether scab is produced by fertilizers. The result was inconclusive.

(b). Preventives of scab. (See also Report for 1887, p. 313.) The tests made in 1888 are summarized in a table in which data of the yield of a row are given. The different substances used were sulphide of potassium, sulphate of iron, sulphate of copper, flowers of sulphur, sawdust, coal ashes, chloride of sodium, wheat bran, ground bone, nitrate of soda, sulphate of potash.

The results obtained are somewhat surprising, and much at variance with results reported by others. The treatment of sawdust and wheat bran, that has been so confidently recommended, proved injurious rather than beneficial, 60 and 61 per cent, respectively, of the yield of those rows being scabby, while the treatment with coal ashes, that is claimed to be favorable to the production of scab, was equally as efficacious as the sulphur, each row producing 18 per cent of the yield that were scabby.

The row treated with sulphate of copper gave the smallest per cent of scabby tubers. This treatment appeared to be the most beneficial of any last season, while the ground bone again was detrimental.

(c) To determine whether the scab is caused by insects. Several hundred hills in various stages of growth were examined for this purpose, but in no case did the scab appear to be due to injuries caused by insects. Experiments with millipedes led to the following conclusions:

(a) Millipedes do not feed upon the sound tubers of the potato.

(b) Their food consists of decaying vegetable matter.

(c) The presence of millipedes in the hills with the scabby tubers was due to the scab, they being attracted by the decayed portion, which they desired for food, and the scab is not due to their presence.

(2) *Smooth versus knobby tubers as seed potatoes* (pp. 227, 228).—This investigation is to be continued through a series of years.

(3) *Tests of insecticides* (pp. 228, 229).—"Zoektein poison" proved as effective in destroying the larvæ of the potato beetle (*Doryphora 10-lineata* Say) as either London purple or Paris green.

(4) *A new insect pest* (p. 229).—Found on quince and plum trees in Geneva, N. Y. Not identified.

(5) *Strawberries*, a test of varieties (pp. 229–231). (See also Report for 1886 and 1887, pp. 253 and 334.)

(6) *Raspberries*, a test of varieties (pp. 231, 232). (See also Report for 1887, p. 336.)

REPORT OF CHEMIST, E. F. LADD, aided by Messrs. Emery, Churchill, and Wheeler (pp. 234–315).

(1) *Fodder analyses* (pp. 235–244).—A large number of fodder analyses are reported. Besides the regular analyses, determinations were made of sugars and starch, and of the albuminoid and non-albuminoid nitrogen by the modified Stutzer cupric hydrate method. The digestibility of the albuminoids of grasses was determined by the pepsin method, and in some cases ash analyses were made for the fertilizing ingredients.

In addition to tables giving the results of analyses made in 1888, tables are given showing the average composition of foods as compiled from analyses made at this Station during the past seven years.

(2) *Amount of fertility removed from the soil by crops* (pp. 244–250).—The results of analyses made during the past two years, and showing the composition of the ash of feeding stuffs and percentages of nitrogen, are given in tabular form, as are the computed amounts of fertilizing matters in one ton of each. The results are also illustrated by graphic diagrams.

(3) *Influence of fertilizers upon the chemical composition of grass* (pp. 250–262).—Experiments in 1887 and 1888. (See also Report for 1887, p. 441.)

In the Report for 1887 are given the results of the investigation of the effects of several fertilizing ingredients on the chemical composition of timothy and clover. In the same year an experiment of a similar kind was made with *Lolium Italicum*. The results of this experiment are tabulated in this report. The results in all the experiments of 1887 showed nothing as to the influence of fertilizers. The following table shows the results secured in that trial from a few of the plats for the timothy:

Composition of dry substances of timothy grass grown with different fertilizers, 1887.

Plat.	Fertilizers.	Ash.	Albumi- noids N x 6.25.	Crude fiber.	Nitrogen- free ex- tract.	Fat (ether extract).
I	Sulphate of potash.....	4.33	6.94	31.13	54.57	3.03
III	Acid phosphate.....	5.11	7.50	32.70	51.04	3.65
XII	Sulphate of potash, sulphate ammonia, and acid phosphate.....	5.15	8.44	31.91	51.16	3.34
XV	Nothing.....	5.54	8.12	30.65	52.62	4.07
XVIII	Sulphate of ammonia.....	5.06	6.94	31.48	53.29	3.53
	Average.....	4.92	7.79	31.75	52.36	3.18

In 1888 the experiment was repeated with mixed grasses, clover, and timothy, and with the following results :

Composition of grasses grown with different fertilizers, 1888.

Plat.	Fertilizers.	Fresh substance.						Dry substance.				
		Water.	Ash.	Albuminoids.	Crude fiber.	Nitrogen-free ex- tract.	Fat (ether extract).	Ash.	Albuminoids.	Crude fiber.	Nitrogen-free ex tract.	Fat (ether extract).
A.....	Sodium nitrate..	66.66	1.44	3.12	12.00	15.69	1.09	4.34	9.37	36.01	47.01	3.27
B.....	Ammonium sul- phate.	65.74	1.39	3.06	11.86	16.59	1.36	4.08	8.94	34.62	48.40	3.96
C.....	Barn manure ...	68.22	1.42	2.32	10.83	16.17	1.04	4.46	7.31	34.08	50.86	3.29
D.....	Potassium ni- trate.	67.26	1.39	2.93	11.89	15.36	1.17	4.24	8.94	36.33	46.91	3.58
E, J, and O.	Nothing.....	67.17	1.53	2.15	11.80	16.35	1.00	4.66	6.56	35.94	49.79	3.05
F.....	Potassium sul- phate.	67.08	1.47	3.08	11.70	16.63	1.04	4.48	6.31	35.54	52.50	3.17
G.....	Muck.....	66.66	1.34	1.90	10.88	18.14	1.08	4.03	5.71	32.64	54.38	3.24
H.....	Bone-black	68.00	1.37	2.06	10.82	16.75	1.00	4.27	6.44	33.78	52.48	3.13
K.....	Bone-black, so- dium, nitrate, and ammonium sulphate.	67.01	1.32	2.92	12.07	15.43	1.25	4.00	8.87	36.59	47.05	3.45
Average		67.09	1.41	2.50	11.54	16.36	1.10	4.28	7.60	35.06	49.71	3.35

The results obtained from this last experiment are the exact opposite of those for 1887. Whenever nitrogenous fertilizers were used there was considerable increase in the albuminoids of the hay, as may be seen by reference to the table :

Observe that the lowest per cent of albuminoids was with muck, and that neither potassium, phosphoric acid (bone-black), nor a combination of these gave any increased per cent of albuminoids. The highest result was with sodium nitrate, and it is further noticeable that the per cent of crude fiber is greatest with the highest per cent of albuminoids.

If we observe the amount of rain-fall for the two seasons we find marked differences. In 1887 the first twenty days of May had only four-one-hundredths of an inch rain-fall

and less than one-half inch for the month. On the other hand, May, 1888, has a record of more than a half inch for the first ten days, and 1.61 inches by the 20th of the month, with a total of 2.79 inches for the month, well distributed over the thirty-one days.

The experiments for the two years led to the following conclusion :

That the application to the soil in the spring of a nitrogenous fertilizer as a top-dressing will be followed by an increase in the per cent of albuminoids of the hay, providing the temperature is favorable, if there is present sufficient soil moisture. But if the soil is not kept moist by rains after the application of the fertilizer, then there will be little or no effect on the chemical composition of the grass.

(4) *Influence of fertilizers upon the chemical composition of oats* (pp. 262-264).—The nature of the experiment and its results are shown in the following table :

Composition of oats grown with different fertilizers.

Plat.	Fertilizers.	Pounds per acre.	Fresh substance.						Dry substance.				
			Water.	Ash.	Albuminoids.	Crude fiber.	Nitrogen-free extract.	Fat.	Ash.	Albuminoids.	Crude fiber.	Nitrogen-free extract.	Fat.
A	Sodium nitrate.....	300	11.11	2.81	14.44	12.40	54.28	4.96	3.16	16.25	13.95	61.06	5.58
B	Ammonium sulphate.	250	11.86	2.81	13.44	11.50	55.03	5.36	3.19	15.25	13.05	62.43	6.08
D	Potassium nitrate....	350	12.07	2.89	13.41	12.76	53.53	5.34	3.29	15.25	14.51	60.87	6.08
E	Nothing.....	.....	11.36	3.22	11.19	12.76	55.88	5.59	3.63	13.75	14.40	61.91	6.31
	Average.....	.....	11.60	2.93	13.12	12.35	54.69	5.31	3.31	15.12	13.97	61.59	6.01

(5) *Increase in corn for the silo as it approaches maturity* (pp. 264, 265).—The corn was sampled for analysis September 11 and 29. The method of taking samples of silage is not stated. The results of the analyses, calculated upon amounts per acre, are as follows :

	Sept. 11.	Sept. 29.
	Pounds.	Pounds.
Yield of corn	23,326	25,011
Dry matter	5,004	5,660
Ash	215	237
Albuminoids.....	525	512
Crude fiber	1,443	1,650
Nitrogen-free extract.....	2,696	3,109
Fat.....	125	188
Water in corn..... per cent.	80.52	77.37

(6) *Chemical composition of hay of several States* (pp. 265-267). (See also Report for 1887, p. 417.)—Analyses of samples of timothy hay received from experiment stations in Wisconsin, Maine, New Hampshire, and New York, in the years 1885-1888, and results of tests of the digestibility of the albuminoids by artificial digestion, are given in tabular form.

(7) *Nitrogen-free extract, starch, sugars and fats of fodders* (pp. 267–270).—The variability in the quantities of these materials in the same kind of fodder material as well as in different materials is referred to, and the bearing upon the nutritive values insisted upon. Determinations of invert sugar, sucrose, and starch in a number of fodder materials are given. Regarding methods of determination it is suggested that—

Analysts have been in the habit of determining all the other constituents of a fodder and taking the nitrogen-free extract by difference. It would be far better to determine the amount of the sugars and starch and take the remainder by difference, even doing away, if necessary, with the determination of the crude fiber.

The difference in the oils and fats of fodder materials and the effects upon the pork and butter produced from them are also discussed.

(8) *Feeding experiments with cows* (pp. 270–284).—Experiments were made (1) with two cows upon the digestibility of feeding stuffs, the amount of nitrogen supplied and recovered, the amount of dung voided and the fertilizing materials contained in it, and the influence of food on milk and butter (to further test the influence of food on milk and butter two other cows were used for a time); (2) with two heifers which received different rations, the total quantities and compositions of the food, the nutritive ratio, and the increase in live weight being determined; and (3) with two other heifers with which the effects of corn fodder and ensilage were compared.

Digestibility of orchard-grass hay.—During the winter of 1887–88 two cows, Jem and Meg, were fed in the experimental barn from December 20 to February 10, the hay fed being from the same general lot of orchard-grass hay in good condition; the first period being hay alone; the second period hay and 8 pounds of corn meal; the third period hay, 2 pounds of corn meal and 5 pounds of linseed meal, and the fourth period hay, 2 pounds corn meal and 8 pounds wheat bran. The animals were weighed each morning before receiving food or drink. Their feed and water were weighed out to them, and all refuse weighed back on the following morning. A record of the milk yield was kept, and analyses of the milk from each cow made so far as our laboratory force would permit. The milk of the two cows was mixed and creamed by the Cooley process for butter, and the salted and weighed butter was carefully sampled and analyzed so that the round of data has been quite complete.

Digestion experiments during the first and second periods were carried out for determining the digestibility of orchard-grass hay and of corn meal, or of a ration of corn meal and orchard-grass hay.

The cow Jem was seven and a half years old, and dropped her last calf February 1, 1887, and was due in calf again in March. Meg, nine years old, dropped her last calf June 25, 1887, and was going farrow at time of experiment.

Each period of feeding for digestion experiment was for ten days, the dung being saved the last four. A man remained with the cows constantly for four days and nights, the urine and dung being received in pails and kept in closed vessels and thoroughly mixed and sampled each morning.

(a) Orchard-grass hay : Jem consumed 19.7 pounds, Meg 18.3 pounds average per day.

	Dry matter.		Albuminoids.		Crude fiber.		Nitrogen-free extract.		Fat (ether extract).	
	Jem.	Meg.	Jem.	Meg.	Jem.	Meg.	Jem.	Meg.	Jem.	Meg.
Total feed	250.25	251.90	24.68	24.64	100.98	96.55	101.87	102.74	9.55	9.54
Dung	100.03	107.14	9.86	9.64	32.60	38.57	43.50	45.93	4.07	4.25
Per cent digested	150.22	144.76	14.82	15.00	67.38	57.98	58.37	56.81	5.48	5.29
Average per cent digested	60.02	57.46	60.06	60.89	66.72	60.05	57.29	55.29	57.42	55.41
	58.74		60.47		63.48		56.29		56.41	

(b) Orchard-grass hay : 17 pounds and corn meal 8 pounds per day consumed by each cow.

	Dry matter.		Albuminoids.		Crude fiber.		Nitrogen-free extract.		Fat (ether extract).	
	Jem.	Meg.	Jem.	Meg.	Jem.	Meg.	Jem.	Meg.	Jem.	Meg.
Total feed	348.355	340.748	35.952	35.395	97.840	94.862	183.727	180.344	13.935	13.719
Dung	121.862	117.741	14.742	12.993	39.683	40.012	54.042	52.227	4.522	4.038
Digested	226.493	223.007	21.210	22.402	58.157	54.850	129.685	128.117	9.413	9.681
Per cent digested	65.01	65.44	58.99	63.29	59.44	57.81	70.59	71.03	67.55	70.56
Average	65.23		61.14		58.63		70.81		69.05	

(c) Corn meal : Digestibility calculated from previous data (assuming the digestibility for the hay in the ration to be the same as when fed alone).

	Dry matter.		Albuminoids.		Crude fiber.		Nitrogen-free extract.		Fat (ether extract).	
	Jem.	Meg.	Jem.	Meg.	Jem.	Meg.	Jem.	Meg.	Jem.	Meg.
Amount digested oz.	226.493	233.007	21.210	22.402	58.157	54.850	129.685	128.117	9.413	9.681
Digested from hay oz.	135.941	136.815	14.226	14.084	64.003	55.817	57.141	53.276	5.265	4.958
Digested from corn meal . oz.	90.552	86.192	6.984	7.318	.....	.....	72.544	74.841	4.148	4.623
Per cent digested	86.75	82.57	56.94	59.66	.....	.....	85.18	89.11	86.99	96.91
Average	84.66		58.35		.....		7.14		91	

The amount of nitrogen supplied and recovered.—The tabulated results show that in the experiment with orchard-grass alone more nitrogen was recovered than fed, showing the ration to be insufficient to maintain the nitrogen balance.

The larger loss being in the case of Jem, with an extra demand made to supply the growth of her fœtus. In the second period [with hay and corn meal] there was stored up considerable nitrogen by both animals, showing that they were receiving more than a maintenance ration.

Dung and the fertilizing material contained in it.—The following tables give the conclusions made from the weighings and analyses of the solid and liquid excreta:

Calculating the amount of dung for a cow 1,000 pounds live weight, both the fresh and dry substance, we have the following average expressed in pounds:

	Period I.		Period II.	
	Fresh.	Dry.	Fresh.	Dry.
Per day.....	44.7	6.8	52.0	8.4
For one hundred days.....	4470.0	680.0	5200.0	840.0
For one year.....	16315.5	2482.0	18980.0	3066.0

From the data already given we may determine the amount in pounds of the various fertilizing elements contained in the manure for one hundred days, also for one year:

	Period I.		Period II.	
	100 days.	One year.	100 days.	One year.
Nitrogen, N.....	10.40	27.97	15.54	56.72
Phosphoric acid, P_2O_5	4.42	16.13	6.55	23.91
Potash, K_2O	8.84	32.26	9.07	33.11
Lime, CaO	8.23	30.03	8.73	31.88

To furnish an amount of fertilizing matter equivalent to that contained in the dung for one hundred days and for one year, also under the different feeds, would require as follows:

	Period I.		Period II.	
	100 days.	One year.	100 days.	One year.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Ammonium sulphate.....	52	189	77	289
Phosphate rock.....	31	115	47	171
Potassium sulphate.....	37	136	39	144

We may now, from the previous data, calculate the total amount of nitrogen contained in the urine, as follows:

	Period I.	Period II.
	<i>Pounds.</i>	<i>Pounds.</i>
Per day.....	0.103	0.101
For 100 days.....	10.340	10.133

The amount of nitrogen in the urine during the first period was almost exactly that contained in the dung, but for the second period there was nearly 5 pounds more in the dung than in the urine for the same time (one hundred days).

(9) *Influence of food on milk and butter* (pp. 284-292).—The results of experiments with the above mentioned and two other cows are given in tabular form, and the following conclusions are drawn from the experiments:

Under hay feed, the lowest milk yield per day was had, but the addition of corn meal to the ration increased markedly the flow of milk. In the two periods following

the corn meal, with linseed meal and with wheat bran, there was a gradual diminution in the milk flow. * * * Although the milk yield fell off considerably in periods three and four over that of period two, yet the absolute amount of fat per day was greatest in period three under linseed-meal feed. * * * We can not, however, attribute the increased fat to the peculiar properties of any particular feed, since the ration in period three was richer in albuminoids than in either of the other periods. * * * Another point shown in these experiments is that the largest milk yield from the same cows does not necessarily give the greatest amount of butter, for in every case we secured the largest amount of butter with a smaller amount of milk produced by linseed-meal feeding.

Does food influence the composition of butter?—This question is discussed from evidence obtained by feeding corn meal, linseed meal, wheat bran and hay. Their influence on the composition of the butter is judged principally by the per cent of iodine absorbed and the viscosity of the soap solutions of the butter fats obtained from the different feeds. The conclusion is that food may affect the composition of butter fats.

(10) *Feeding experiments with two heifers* (pp. 292–297). (See also Report for 1887, pp. 23–26.)—Two heifers, Bess and Jess, weighing respectively 1,106 and 903 pounds, at the beginning of the series of experiments received hay, oat straw, corn meal, wheat bran, cotton-seed meal, and roots in different amounts and proportions, in experiments lasting through three periods of thirty-two to thirty-four days each. They gained in the three periods respectively: First period, 31 and 36 pounds; second period, 72 and 41 pounds; third period, 62 and 57 pounds.

The total dry matter per day consumed for each period by the two animals is shown by the following, expressed in pounds:

Period.	Bess.	Jess.
1.....	17.34	14.34
2.....	21.69	12.98
3.....	22.61	18.80

According to German standards, Bess called for 24 to 26 pounds dry matter per day and Jess 20 to 24 pounds. As a matter of fact, they were at no time induced to eat this amount of dry matter. Bess, weighing about 1,100 pounds, made her best gain on 21.69 pounds dry matter per day, and Jess, weighing about 1,000 pounds, ate but 12.98 pounds per day in the second period, when straw formed a part of the ration.

Taking the figures for the digestion coefficients from Armsby's Manual of Cattle Feeding for the feeds used in the several rations, we have for the nutritive ratio as follows for Bess:

Period.	Nutritive ratio.	Gain per day.
		<i>Pounds.</i>
1.....	1: 5.69	.97
2.....	1: 10.	2.11
3.....	1: 4.88	1.89

Calculating in the same manner for Jess, we have the following:

Period.	Nutritive ratio.	Gain per day.
		<i>Pounds.</i>
1.....	1: 9.78	1.12
2.....	1: 6.25	1.21
3.....	1: 4.82	1.73

Based on these figures, we find Bess made the largest gain per day on the widest nutritive ratio; that is, with corn-meal feed. Jess, on the other hand, made a better gain through each period as the nutritive ratio was narrowed.

(11) *Corn fodder vs. ensilage* (pp. 297-299).—These feeding experiments were performed with two Jersey heifers, Belle and May. Each received $8\frac{2}{3}$ pounds of hay and 3 pounds of linseed meal per day, and, in addition, in one period, corn fodder, and in another period ensilage *ad libitum*.

In each period when ensilage was fed as a part of the ration, in comparison with corn fodder, we find that a larger amount was eaten of dry matter as ensilage, and there was a marked increase in weight, while with the corn fodder the gain was small in the first period with Belle, and in the second period there was a loss of weight by May.

(12) *Sheep-feeding experiment for fat and lean meat* (pp. 300-303).—The results given indicate that the gain in favor of lean meat can be largely influenced in the case of lambs by proper feeding. Data regarding the weights of the several organs of the animals are given.

(13) *Artificial vs. animal digestion* (pp. 304-307).—From the experiments reported and other data the following conclusions are drawn:

(a) That pepsin digestion furnishes us a reliable means of determining the digestibility of the albuminoids of our feeding stuffs, thus serving as a criterion of the digestibility of the fodder itself.

(b) That the coefficients of digestibility for all foods, as usually calculated from animal digestion, are too low.

(c) That the coefficient of digestibility for the albuminoids of corn meal seems to be too high for ruminants.

(d) That in many of our feeding stuffs all of the albuminoids seem to be in a digestible form.

(e) That the digestion of the faeces by a pepsin solution may, and probably does, in many cases digest a portion of the food which was undigested by the animal; that is, if we add to the results secured with the animal the amount digested from the faeces by a pepsin solution, the coefficient of digestibility will be too high.

(14) *Analyses of commercial fertilizers* (pp. 307-312).

During the past year a much larger number of fertilizers have been received for analysis at the Station than in any previous year. At least one sample has been analyzed of such brands as have been sent in accordance with the instructions furnished by the Station for sampling and shipping and the results reported to the interested parties.

(15) *Amount and analyses of drainage from each lysimeter for 1888* (pp. 313-315).

REPORT OF FARM SUPERINTENDENT, F. E. EMERY (pp. 316-403).

The time of the farm superintendent has been largely occupied in permanent improvements of the water supply, also on drains and water-pipes on the station grounds, feeding experiments, and in superintending the labor on the station farm. Much time has also been devoted to the new barn.

(1) *Soil and rotation of crops* (pp. 316, 317).

The heavy clay soil which constitutes the main part of the farm is capable of producing fair average crops under favorable conditions. It is proposed to increase the fertility by a rotation of crops, with at least one application of manure from the stables (with corn crop) in each course. This may be supplemented by a top-dressing or application of commercial fertilizers to one or more of the other crops as may be deemed expedient.

The course of rotation started is :

- (a) Corn on turf.
- (b) Forage, consisting of corn and sorghum and other green crops for soiling and ensilage, and roots.
- (c) Grain crop with seeding for grass.
- (d) Hay for two years.

The accompanying tabular statement of crops produced and those proposed for next season will convey a clearer idea of the rotation than a written description :

Rotation of crops produced and proposed on the Station farm.

Year.	Field C, 10.53 acres.	Fields D and E, 24.73 acres.		
		Field D.	Field E.	
1882....	Pasture	Part in wheat and part in timothy.	Part in wheat and part in timothy.	
1883....	do			
1884....	Oats	Wheat	Corn.	
1885....	Corn	Clover	Oats.	
1886....	High part seeded on corn rows for pasture.	Clover and timothy	Wheat.	
1887....	Pasture; the low part of this field is within the banks of Castle Brook, and has been in permanent pasture.	Corn and millet	Clover and timothy.	
1888....	Permanent pasture	Oats (seeded), alfalfa, and grass plats.	Corn.	
1889....	do	Clover or wheat, alfalfa, and grass plats.	Forage.	

Year.	Field F, 10.8 acres.	Field G, 10.37 acres.	Field H, 10.45 acres.	Fields I and J, 14.95 and 2.4 acres.
1882....	.....	.....	.....	Permanent pasture.
1883....	Wheat	Barley .....	.....	Do.
1884....	Clover hay	Fallow	Pasture	Do.
1885....	Corn	Wheat	do	Do.
1886....	Oats	Wheat seeded for clover and timothy.	Corn	Do.
1887....	Wheat seeded for clover and timothy.	Hay	Oats	Do.
1888....	Clover hay	Clover and timothy hay.	Ensilage and soiling crops.	Corn.
1889....	Timothy	Corn	Grain	Oats.

This plan provides for no money crop to be sold from the farm, but is adapted to make a more finished product from the stable the source of income. This seems to be the true course for a large class of our farmers.

In favor of this plan a table and diagram are given showing the quantities of fertilizing elements (nitrogen, phosphoric acid, and potash) sold from the farm in 2,000 pounds of animal and vegetable products, including crops, fat animals, milk, butter, and cheese. Taking the market price of the products to be sold and subtracting the value of the fertilizing elements, the remainder represents the cost of seed, interest, taxes, labor, and, last of all, profits.

In the refined animal product, while the percentage of fertilizing elements lost in a given weight sold is greater than in an equal weight of the field crops, yet this animal produce contains but a small percentage of the fertilizing value of the coarser crops from which it was derived. The greater part is left behind, while the ratio of net income has increased so much that the field crop can be paid for and used as animal food, leaving a handsome margin for profit, where the bulkier crop could not repay cost of handling in shipment to consumers. Such articles should be consumed as near the spot where produced as possible, because of the small margin above the fertilizing value received for them, and every farmer should study to change all the products of his farm and labor from the coarse, bulky forms, from which little can be realized on the market, to a fertilizing material and a more finished product, which yields a better return.

It will be seen by the table * * * that the amount of fertilizing matter in one ton of milk is a little less than in either one ton of wheat straw or potatoes, while * * * the market value of the fertilizing matter in milk is greater than that of either potatoes or wheat straw. This is due to the greater amount of nitrogen, the most costly of fertilizers, and of which potatoes contain less than either wheat straw or milk. Carrying this comparison further, and assuming 20 bushels of wheat or 100 bushels of potatoes to be the product of one acre, and that the yield of grain to straw is as 100 to 112.5, the net income (minus value of seed) from one acre of wheat becomes \$18.38, while that of 1 acre of potatoes is \$71.34. Deduct for 2 bushels of seed wheat \$3, and for 24 bushels of potatoes \$18, and the comparative net income becomes \$15.38 and \$53.34, respectively.

Similar comparisons can and should be made with other articles.

If these prices vary much from those of any particular locality, it will only be necessary to add to or subtract from the net income an amount equal to the variation, in order to adapt the method and settle on a comparatively profitable crop.

The report contains an account of crops produced on the station farm, including yields per acre and other data, and of the silos and their contents.

(2) *Out-door silos* (pp. 326-331).

In 1887 the first out-door silo in this country was made here at the instance of Mr. James Wood, of Mt. Kisco, N. Y., who also furnished a set of the levers such as are used in England for compressing the same.

(See Report for 1887, page 73, for an account of this silo and condition of the ensilage September 30, 1887.)

(3) *Sorghum (saccharatum)* (p. 331).—This was grown very successfully as a green-fodder crop, despite the fact that the land was a poor knoll where not more than two-thirds of the plants were able to get a fair stand. The yield was at the rate of nearly ten tons per acre and “would have undoubtedly been doubled or trebled with favorable weather.”

Early Amber, Link's Hybrid, and Early Orange were tried; the Early Amber appeared most desirable because the earliest.

(4) *Alfalfa, or lucern (Medicago sativa)* (pp. 331, 332).

This valuable forage plant has been cultivated on the station plats since 1882 and reported upon favorably, hesitatingly at first, but with more confidence as its tenacity of life and heavy crops produced carried the conviction that it is one of the profitable forage crops for New York. Writers cling to the recommendation of sandy soil for alfalfa, but here on stiff clay it has thrived since 1882 on the original seeding. Later seedings have yielded well, and to all appearances it is perfectly hardy when well established. It is a little difficult to get a perfect "stand," and makes a slow growth the first year. Hence, weeds are apt to choke it; but if past its first season, dairymen can depend on a fair clover crop from it for several years in succession.

(5) *Prickly comfrey (Symphytum asperrimum)*, (pp. 332, 333).

Trials this season * * * indicate that the plant is of no value for hay or ensilage. Its value as an agricultural plant is therefore confined to the soiling system. It appears to be a valuable addition to our list of soiling crops. The station cows have eaten heartily of it whenever offered to them, and they have consumed the entire crop, except the portions which were used in trials for hay and ensilage.

(6) *Grasses on small plats, 1888* (pp. 333-337).—Brief notes on the appearance and condition of grasses and clovers which survived the winter.

There are several which in earliness and other good qualities seem well fitted to rank with the favorite timothy. The best of these for hay are *Festuca elatior* and *pratensis*, *Dactylis glomerata* and *Avena elatior*. For early hay, where the stubble is to be grazed, there seems to be no grass which can equal *Poa pratensis*, and *Alopecurus pratensis* is well fitted to take a place in the good pasture grasses.

June grass (*Poa pratensis*) has come into disrepute in most sections of the Northern States as a field or pasture grass. This is chiefly due to its early ripening, after which there is only a small crop of wiry hay. Cattle will wander over it when ripe, standing 15 to 24 inches high, searching for something to eat. When cut at an early stage of growth, soon after the panicle is grown or when in blossom, or if fed off close at that time, its leaves will go on growing from the base all the season, and in that way it yields an incredible amount of pasturage. This grass makes the strongest of turfs, and cattle are less liable to do injury with their feet, if grazing when too wet, than on most other turfs.

The less well-known grasses which seem to promise to yield large crops and to be available for hay are—

Sorghum halepense, which with *Melilotus* makes an excellent hay in Mississippi. It grows here as an annual, but may undoubtedly be cut twice in one season by careful management and under very favorable circumstances. It is to be tried on a larger scale.

Phalaris arundinacea, although a coarse and rather harsh grass, starts early and is a rank grower, and seems to be perfectly hardy here. It makes a rapid growth early in spring, and has been eaten once (the only time offered to them) with relish by the station cows. It can spread by its stout root-stalks, and might become a troublesome weed on that account if introduced where not wanted permanently. However, no such trouble has been experienced with it yet.

The new clovers have made a good thick growth, especially *T. incarnatum* and *Medicago maculata*. The former may not survive the winter in this latitude, since it is a subtropical plant. It blossomed and would have yielded quite a crop if it had been cut seasonably.

(7) *Large grass plats* (pp. 337-350).—Notes on plats seeded to grass in 1886. Mixture sown and condition early in spring, with table of yield per acre of hay from each plat.

(8) *Fertilizer experiment on grass* (pp. 340-343).—This was intended as a fertilizer and soil test. One-sixth acre plats were laid off and divided into two fields. The growth on one field was clover and timothy, with an excess of clover; on the other field timothy was the predominant grass, with a small amount of clover.

The plats were fertilized with some ten different kinds of commercial fertilizers, singly and mixed, and with muck and barn-yard manure. The nitrogenous fertilizers were the only ones that showed any marked effect, and sodium nitrate was the only fertilizer from which a profitable return was realized.

(9) *Fertilizer experiment in field D—Oats* (pp. 344-348).—The question here was: What elements, or combination of fertilizing elements, does this field require in order to produce the largest and most profitable crop?

Nitrogenous manure had the effect to increase the size and green color of straw and to lengthen the growing period, or, in other words, to retard ripening, while phosphoric acid had its effect in hastening the ripening of the crop.

Neither muck, potash, nor gypsum had any noticeable effect on the appearance of the crop.

Not one of the manured plats produced enough more than the mean of the three unmanured plats to pay for the fertilizer used.

(10) *Fertilizer experiment in field E—King Philip corn* (pp. 349-356).

This field produced a crop of hay in 1887. It received a dressing of muck and manure, composted the following spring, at the rate of thirty loads per acre. This dressing was plowed in May 10-16. The ground was harrowed several times.

The heavy roller was run over it the next day, and a light rain following before morning gave the seed a good chance to grow. The corn rows were obliterated by rolling, and remained so until the corn was up. The fertilizers were sown and muck and manure applied on the 8th.

This crop is so uniformly good, that there is but one conclusion to draw: With the thirty loads of manure per acre plowed in the corn was so well fed, that a further application was unprofitable and its effects scarcely noticeable, although there was, on the whole, a somewhat larger crop per acre than on the remainder of the field. There seems to have been an increase in the ratio of stover to sound corn from the plats which received nitrogen alone. This is in accord with the influence of nitrogen on our other plats.

The most important and interesting part of this experiment is its bearing on the selection of plats which shall represent the field in which they are located. Being in strips extending across the whole field, they offer a fine opportunity for testing the relative fertility of different portions of the field, or, in other words, the fallacy of using small plats and generalizing on the evidence of data so obtained.

This is in accord with the influence of nitrogen on the other plats.

(11) *Fertilizer experiment with corn* (pp. 356-363).—This is an account of the first of a series of experiments with fertilizers for corn, planned to continue several years with the same materials on the same plats.

(12) *Water supply* (pp. 364, 365).—Account of the work done to improve the supply of the Station.

(13) *The new barn* (pp. 365-369).—The report contains a description of the barn and the object held in view in its construction.

(14) *Meteorology for 1888* (pp. 370-403).

Cornell University Agricultural Experiment Station.

Department of Cornell University.

Location, Ithaca.

Director, Isaac Phillips Roberts, M. Agr.

FIRST ANNUAL REPORT, 1888.

REPORT OF DIRECTOR (pp. 7-9).—The report contains an account of the organization and equipment of the Station.

Four bulletins have been issued, in editions of 4,000-5,000 copies. "So widely have they been reproduced by the journals (in one case a republication of 2,500 copies of the entire bulletin having been made for private distribution), that it may be safely said they have been read by over 600,000 farmers."

REPORT OF CHEMIST, G. C. CALDWELL, Ph. D. (pp. 13, 14).—The following is the summary of analyses made at the Station up to December 26, 1888:

Fodders	25
Fertilizers	3
Feeding experiments	6
Miscellaneous	32
Total analyses	66

REPORT OF BOTANIST, A. N. PRENTISS, M. S. (pp. 15, 16).—The report contains an account of the organization of this department.

REPORT OF CRYPTOGAMIC BOTANIST, W. R. DUDLEY, M. S. (pp. 17, 18).—The report contains an account of the organization of this department.

REPORT OF ENTOMOLOGIST, J. H. COMSTOCK, B. S. (pp. 19-21).—Two papers were published during the year: (1) On Preventing the Ravages of Wire-Worms; (2) On the Destruction of the Plum Curculio by Poisons.

Among the subjects now under investigation are the following:

Wire-worms.—A study of their habits and transformations and experiments in preventing their ravages.

A disease of the clematis.—This destroys a large proportion of the plants grown by nurserymen in this State. The roots of the diseased plants are usually, if not always, infested by worms belonging to the family *Anguillulidæ*. I do not yet feel sure whether these worms are the cause of the disease or whether it is produced by a fungus, as stated by Arthur.*

A saw-fly destructive to wheat.—The larvæ of this insect live within the stalk, and when fully grown make their cocoons in this place just above the root. The stalk is nearly severed above the cocoon. The adult saw-fly has not yet been grown. The habits of the insect are very similar to a well-known European species of this family, *Cephus pygmaeus*.

* Report New York State Experiment Station, 1884, p. 383.

The formation of knotty growths in pears and apples.

A borer in blackberry.

A borer in celery.

Wintering bees.

REPORT OF HORTICULTURIST, L. H. BAILEY, M. S. (pp. 25, 26).—The report contains an account of the organization and equipment of this department.

BULLETIN NO. 1, MAY, 1888.

The experimental dairy-house of the Station. The bulletin contains a detailed description of the dairy-house erected on the university farm in 1885. The account is illustrated with plans.

BULLETIN NO. 2, AUGUST, 1888.

Experiments with lambs to determine the effect of nitrogenous and non-nitrogenous foods on the fat and lean meat, and also the economic value and effect on health and digestion of foods rich and poor in nitrogenous compounds.

From a flock of about 100 lambs, six months old, six were chosen with great care with reference to uniformity in size, weight, and shape. They were mixed Cotswold and Southdown blood.

Their food from weaning to October 10 had been grass alone.

On the above date they were shorn and all placed together in a box-stall, and prepared for the experiment by being fed hay, and at first with a small portion of corn meal and bran, which was gradually increased until it reached on November 11, when the experiment began, about three-fourths of a pound per head.

From this time on they were divided into two lots of three each in such a way as to make the total weight of each as nearly equal as possible. They were provided with warm stalls on the ground floor of the barn. In order to make the feeding rations different in character, lot one at the beginning of the experiment was fed daily $1\frac{1}{2}$ pounds of oil meal and $1\frac{1}{2}$ pounds of coarse wheat bran. Later on in the experiment, in order to make the nutritive ratio still narrower, one pound of cotton-seed meal was substituted for one of bran.

Lot two was fed 3 pounds of corn meal daily.

Both lots were fed good mixed timothy and clover hay, great care being taken to give them only as much as they would eat up clean.

All ate their rations with avidity up to near the last of December, when that of lot two had to be reduced for a short time to 2 pounds, and later on, for three days, they received nothing but hay, as they refused to eat their corn meal; it was not until March 1, when 4 pounds of mangels were added to the rations of both lots, that they could be induced to eat their full ration.

According to the German standards of feeding rations, one to four is the narrowest (that is, *one part* of protein, or muscle-producing food, to *four parts* of carbohydrates or heat and fat producing), and one to seven the widest ratio advisable for the purpose of fattening sheep. Since the nutritive ratio of the food of one lot was below the lower of these ratios, and that of the other above the higher, it is natural for us to expect very marked results. These results were noticeable almost from the beginning of the experiment. The lambs of lot one were livelier, more sportive, plumper, and showed far better development and growth than those of lot two.

The difference in the amount of water that was drunk as the experiment progressed was very marked. Lot one drank 61 pounds in six days; lot two, $21\frac{1}{2}$ pounds. The solid voidings were of a very different character; those of lot one being soft, while

those of lot two were hard and dry, up to March 1, when the ration of mangels was added.

It was evident by March 1 that lot two would not become fat enough or have sufficient development, without some change in the ration, to compare with lot one; so a change of ration became necessary. Table I shows that the added root ration not only toned up the digestion of lot two, and enabled them to consume more corn meal than they could without it and to make a gain of 2 per cent more in one month than they had in the two previous months, but it also shows that lot one was greatly benefitted by the addition of roots to their food. Their average gain in live weight for the preceding periods was $11\frac{1}{4}$ per cent. The addition of the roots apparently increased it to 16 per cent.

The average gain of lot two for the same period was $7\frac{1}{2}$ per cent. The addition of the 4 pounds of roots increased this to 13 per cent.

The following table shows the result of the experiment:

Tables showing weight of vital organs and amount of pressure required to break the bones of the right hind legs.

WEIGHT OF VITAL ORGANS.

	Live weight, including wool.	Dressed weight.	Wool.	Blood.	Skin.	Spleen.	Heart.	Liver.	Lungs	Head.	Kidneys.	Caul.	Viscera.
	Lbs.	Lbs.	Lbs. oz.	Lbs.	Lbs. oz.	Oz.	Oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Oz.	Lbs. oz.	Lbs.
Lot I:													
No. 1.	88	43.5	3 1.5	3	6 7.75	1.5	5.5	1 8.5	1 8.5	3 .5	4	4	17.5
No. 2	73	37.5	3 1.75	3	5 .5	1.25	5.5	1 6	1 3.25	2 15.5	3	1 13.5	16
No. 3	77.5	37.5	3 14.25	3	6 11.25	1.75	5	1 10	1 8	2 14.25	3	3 3	16.5
Total ..	238.5	118.5	10 1.5	9	18 3.5	4.5	16	4 8.5	4 3.75	8 14.25	10	9 .5	50
Lot II:													
No. 1.	60	26	2 7.5	3	4 8	1	5	1 3	1 4	2 13	2.5	2 5.25	15
No. 2.	65.5	30	1 9.25	2	4 7	1	5	1 7.75	1 2.5	2 12.5	2.25	1 7.5	20
No. 3.	69.5	32.5	2 8	3	6 3	1.5	6.5	1 3	1 5	3 2.5	2.5	2 12	15
Total ..	195	88.5	6 8.75	8	15 2	3.5	16.5	3 13.75	3 11.5	8 12	7.25	6 8.75	50

PRESSURE REQUIRED TO BREAK THE FOLLOWING BONES OF THE RIGHT HIND LEG:

	Meta tarsal.	Tibia.
	Lbs.	Lbs.
Lot I:		
No. 1.....	381	450
No. 2.....	385	432
No. 3.....	325	442
Total	1,091	1,324
Lot II:		
No. 1.....	289	333
No. 2.....	281	379
No. 3.....	325	358
Total	895	1,070

Although this experiment is but one of a series to be tried here at the Experiment Station, and needs to be repeated many times before absolutely accurate results can be obtained, yet we may deduce from it that the effect of feeding an undue proportion of non-nitrogenous food to sheep is—

(1) To decrease the production of wool by one-quarter.

- (2) To decrease the strength of the bones by one-third.
- (3) To reduce the production of both fat and lean meat.

Not one of these three important effects is desirable in sheep husbandry ; hence we may conclude that corn alone is not the best food for sheep.

In these experiments in feeding lambs there appears to be no evidence that the ration rich in nitrogen caused any marked increase of lean meat in lot 1 over lot 2. If younger lambs had been selected it is quite possible that the result might have been different. It is probable that common sheep will not respond to a ration rich in protein as do pigs, for the reason that they have not, through long years of breeding and feeding, had the tendency to put on a large per cent of fat bred into them. It is also probable that the results would have been different had lambs been selected whose ancestors from remote periods had been kept excessively fat.

The effect of a ration rich in carbohydrates is so marked in these experiments that it deserves careful consideration.

The bulletin also contains tables showing the details of the experiments and plates illustrating the comparative disposition of fat and lean meat on lambs of both lots.

BULLETIN NO. 3, NOVEMBER, 1888.

(1) *The insectary*.—The bulletin contains a description of the new insectary of Cornell University and its equipment. The account is illustrated with pictures of the exterior of the insectary and a root-cage.

(2) *On preventing the ravages of wire-worms* (illustrated).—The bulletin contains a description of wire-worms and of click beetles (*Drasterius dorsalis*).

On preventing the ravages of wire-worms by trapping the beetles.—At the beginning of our study of wire-worms experiments were tried to ascertain if it were practicable to protect the seed and young plants in a corn field by furnishing the worms with other food. Baits of sliced potatoes, clover, corn meal dough, and corn-meal dough sweetened with sugar were placed in various positions in a badly infested field. This was soon after the field had been planted and before the corn came up. In most cases the baits were placed on the surface of the ground and covered with small boards. Boards were used instead of earth for covering the baits to facilitate the examination of them. It now seems probable that more worms would have been attracted had the baits been buried. We purpose to investigate this point next year.

The results of our efforts to trap wire-worms were very different from what we had expected. A few were taken in traps baited with sweetened dough; not enough, however, to be of much practical importance; but to our surprise large numbers of click beetles were taken. This at once opened a new line of investigation. If it is possible to trap and destroy the beetles before they have laid their eggs we have at our command a much more effectual method of preventing the ravages of wire-worms than by destroying the larvæ after they are partially grown.

As indicating the possible efficiency of this method, I will cite a single instance. A series of twelve traps, which had been left undisturbed for only three days, yielded four hundred and eighty-two beetles, or an average of more than forty beetles per trap; and this notwithstanding that a considerable number had been attracted to other traps in the immediate vicinity.*

It does not seem worth while to publish the details of these experiments, as we purpose to go over the same ground again and to carry the work much farther. The

* More than one-half of the click beetles collected in these experiments were *Agriotes mancus*. Next in abundance was *Drasterius dorsalis*. A few specimens of *Agriotes pubescens* were also taken.

following are some of the results obtained: Of the substances used as baits clover attracted by far the larger number of beetles. It should be noted in this connection that a neighboring field, separated from the corn field only by a lane, is a clover meadow. The average distance of our traps from the meadow was less than 10 rods. It is a matter to be questioned whether the beetles spread from the clover field or whether the proximity of this field lessened the number in the corn field on account of the greater attractions of the clover. The clover baits were small bunches, about one-quarter pound in weight, of freshly cut clover.

Of the baits used sweetened dough comes next in the order of efficiency. This was made by mixing one part sugar with ten parts corn meal, and sufficient water to make a dough. About one-half tea-cupful was used in each trap. Unsweetened dough and sliced potatoes proved to be of nearly equal value, but much less attractive than sweetened dough.

In one series of experiments the same number of traps were baited with each of these substances, except potatoes, and were placed as nearly as possible under similar conditions. Three per cent of all the beetles taken were in the traps baited with unsweetened dough; 31 per cent of them in those baited with sweetened dough, and 65 per cent in those baited with clover.

Experiments were tried to determine whether the beetles fly by day or by night. A series of twenty-four traps were examined at 6 p. m. and at 6.30 a. m. At each examination the bait was replaced with some that was fresh. Thirty-two and one-half per cent. of the beetles were taken at the evening collections and 67½ per cent. at the morning, indicating that the insects fly both by day and by night, but are more active in the night-time.

In another experiment, twenty-four traps were placed in a line extending from a hill on one side of the badly infested portion of the field through this part to the opposite hill. The bait was clover. Twelve of the traps consisted of shallow pie-tins sunk into the earth, so that the upper edge of the tin was even with the surface of the soil, and the other twelve traps were cake-tins with nearly vertical sides three inches high; these cake-tins were not sunken into the ground. In both cases the bait was uncovered. The pie-tins and cake-tins were placed alternately; 13 per cent of all the beetles taken were in the deep tins, and 87 per cent in the shallow tins. We conclude, therefore, that although the beetles fly readily, they seek their food chiefly by running over the surface of the ground.*

The following insects were also found in the click-beetle traps: Ground beetles (*Pterostichus lucublandis*), Indian Cetonia (*Euphoria inda*), and *Ips fasciatus*.

In pursuing click beetles the best results were obtained with clover which had been dipped into Paris-green water, and clover wet with a 10 per cent aqueous solution of an arsenical poison sold under the name of Zoektein. The bait in these cases consisted of a small handful of freshly cut clover, weighing about 3 ounces, dipped into the poisoned solution, and covered with a small board. The covering was to prevent as much as possible the drying of the clover.

(3) *On the destruction of the plum curculio by poisons.*—The article gives an account of observations made to determine whether the adult beetles are destroyed before they lay their eggs or whether the poison reaches the young larvæ. In the latter part of August curculios were found hiding in small pits eaten into apples in an orchard.

* The following indicates the number of beetles taken from each of the twenty-four traps at a single examination, that of June 2. The figures are arranged in the order of the traps; those in bold face indicate the number taken from the shallow tins: 10, 19, 5, 27, 2, 51, 4, 46, 11, 68, 0, 52, 2, 55, 10, 69, 13, 54, 5, 31, 1, 0, 11, 10.

Several perfect apples were then selected and placed in breeding cages, in each of which were confined several curculios. The question was soon settled; within twenty-four hours the beetles had begun to eat into the apples. They made small holes at first, but these were soon enlarged so as to form pits of the size indicated above. We thus see that the plum curculio is a voracious feeder, and conclude that spraying of the plum trees early in the season with Paris-green water protects the fruit by the destruction of adult curculios before they have laid their eggs.

This conclusion is confirmed by the observations made elsewhere.

BULLETIN NO. 4, DECEMBER, 1888.

Growing corn for fodder and ensilage.—The following tables give the results of experiments to determine the relative value of different methods of growing corn for fodder and ensilage:

Table I.

Plat.	Mode of culture.	Yield per acre.	Water.	Dry matter per acre.	Yield.
		<i>Pounds.</i>	<i>Per cent.</i>	<i>Pounds.</i>	<i>Per cent.</i>
	Sibley's Pride of the North:				
1	Hills 3 by 3 feet	20,610	} 78.50	4,431.3	86.9
6	Hills 3 by 3 feet	21,370			
2	Drills 3 feet apart	24,555	} 78.45	5,291.6	100
5	Drills 3 feet apart	23,760			
4	Broadcast, no culture	14,535	78.02	3,196	60.2
3	Broadcast, harrowed	17,065	79.56	3,488	70.6
	Eight-rowed flint:				
7	Listed, hills 3 by 3 feet	19,705	79.45	4,049.5	81.6
8	Planted, hills 3 by 3 feet	18,195	77.21	4,099.3	75.3

Table II.

Plat.	Mode of culture.	Dry matter per acre.	Protein in dry matter.	Fat in dry matter.	Carbohy- drates in dry matter.	Protein per acre.	Fat per acre.	Carbohy- drates per acre.
		<i>Pounds.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
1	Hills	4,431.3	10.06	2.18	83.72	445.8	96.6	3,709.9
2	Drills	5,201.6	10.00	2.10	83.71	529.2	111.1	4,429.6
4	Broadcast	3,196	7.19	2.41	83.48	229.8	77	2,668
3	Broadcast, harrowed	3,488	7.56	1.64	86.03	263.7	57.2	3,001.3
*7	Listed	4,049.5	13.12	2.45	76.32	531.3	99.2	3,090.6
*8	Planted	4,099.3	10	2.66	81.97	409.9	109	3,360.2

* Eight-rowed flint, the others Sibley's Pride of the North.

Table III.

	Mode of culture.	Yield per acre.	Dry matter per acre.	Value per acre in com- parison with tim- othy hay at \$12 per ton.
		<i>Pounds.</i>	<i>Pounds.</i>	
Timothy hay		3,000	2,595	\$18.00
Plat 1	Hills	20,610	4,431.3	30.08
Plat 2	Drills	24,555	5,291.6	35.74
Plat 4	Broadcast	14,535	3,196	19.72
Plat 3	Broadcast, harrowed	17,065	3,488	21.64
Plat 7*	Listed	19,705	4,049.5	29.15
Plat 8*	Planted	18,195	4,099.3	27.88

* Eight-rowed flint, the others Sibley's Pride of the North.

BEST PERIOD FOR CUTTING.

Table IV.

Period.	Date of cutting.	Yield per acre.	Water.	Dry matter per acre.	Protein per acre.	Fat per acre.	Carbo-hydrates per acre.
		<i>Pounds.</i>	<i>Per cent.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
I	July 24.....	18,762	89.34	2,000	250.6	42	1,543.6
II	August 8.....	24,578	83.57	4,039	368.4	81.99	3,328.9
III	September 3.....	27,674	73.93	7,214.2	585.8	199.1	6,166.7

Table V.

	Date of cutting.	Total yield per acre.	Dry matter per acre.	Feeding value in comparison with timothy hay at \$12 per ton.
		<i>Pounds.</i>	<i>Pounds.</i>	
Timothy hay		3,000	2,595	\$18.00
Period I.....	July 24	18,762	2,000	14.05
Period II.....	August 8	24,578	4,039	26.16
Period III.....	September 3	27,674	7,214.2	47.33

NORTH CAROLINA.

North Carolina Agricultural Experiment Station.

Location, Raleigh.

Director, H. B. Battle, Ph. D.

ANNUAL REPORT FOR 1888.

REPORT OF DIRECTOR (pp. 3-14).—The report contains an outline of the work of the Station, showing that its scope has been largely increased since the Station began to receive the benefits of the act of Congress of March 2, 1887.

It now includes—

I. *Chemical and microscopical work*, including the analyses of fertilizers, agricultural chemicals, composts, and home-made fertilizers, and all materials from which they can be made; soils, marls, mucks, feeding stuffs; potable and mineral waters; milk, butter, and other dairy products; examination of seeds; grasses and weeds; the study of insects injurious to vegetation.

II. *Experimental work in the field, stable, and laboratory*, to include the effect of different fertilizers on various soils of the State; the study of improved methods for cultivation of the staple crops; treatment for worn-out lands; rotation of crops; tests of new crops; chemical investigations, with practical experiments with cattle on the value of the various forage crops; ensilage; and feeding experiments.

III. *The collection and distribution of meteorological data*, such as will directly aid the various agricultural industries of the State.

IV. *A bureau of information* for all subjects connected with the agricultural industries of the State.

There is also a brief account of the equipment of the Station.

Chemical Work (pp. 7-9).

(a) *The fertilizer control*.—As an evidence of the value of this branch of the Station's work the following table is given, showing the average composition of ammoniated fertilizers analyzed at the Station from 1880 to 1888, and their relative valuation on the basis of the valuation for 1888:

Average composition of ammoniated superphosphates with potash.

	1880.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
Available phosphoric acid.....	7.40	8.91	8.59	8.15	9.13	8.69	8.54	9.11
Ammonia.....	2.70	2.60	2.33	2.67	2.65	2.53	2.43	2.61
Potash.....	1.30	1.82	2.18	2.13	2.34	2.30	2.08	2.33
Valuation on 1888 basis.....	\$18.28	\$20.61	\$19.48	\$19.92	\$21.25	\$20.33	\$19.62	\$21.19

In 1877, when the Station was established, the average cash price of the ammoniated fertilizers was \$43.50 per ton. This same fertilizer in 1888 could be bought for \$27.50, a reduction in price of \$16 per ton. It is not claimed that the Station was the sole cause of this reduction, but that by a judicious control of the trade in renewing confidence between the dealers and consumers, in the prevention of fraud, in producing healthy competition, it aided largely toward this end.

(b) *Experimental chemical work*.—The main feature of this work for the past year has been the investigations on the "Chemical History of the Cotton Plant from Seed to Maturity," which are extensive and not completed.

Numerous samples of forage plants and grasses which have never before been analyzed in this section have also been examined at this Station during the past year.

(c) *Miscellaneous chemical work*.—The following is a record of the chemical work done in 1888:

Commercial fertilizers analyzed for the Fertilizer Control.....	158	Potash salts.....	11
Fertilizers (for farmers)	32	Composts	18
Cotton-plant experiments.....	117	Cotton-seed products	7
Mineral waters	69	Manures	2
Drinking waters	23	Tobacco stems	3
Grasses and seed identified.....	78	Peat	2
Ores	78	Water for boiler.....	2
Marls	24	Wine and beer	2
Phosphates.....	17	Miscellaneous	13
Soils	19	Total	673

Experimental farm work (pp. 9-11).

Field experiments.—Owing to lack of funds the work of the Station in this direction was limited to the latter part of the year. Much of the work after this time was preparatory in its nature. Experiments are now being conducted, however, on the yield of wheat with the various fertilizing ingredients compared with the effect of turning under pea

vines; on the value of a forage plant new to the South—prickly comfrey—which promises well for this climate, so disposed to extended droughts; on the practical operations connected with corn ensilage, and other minor work of more or less importance. Co-operative experiments with fertilizers on the staple crops of the State were carried on by individual farmers in various counties under the direction of the Station. This is a new enterprise in North Carolina. Buildings and equipment have been provided, and other preparations made for feeding and dairy experiments.

Botanical work (pp. 11, 12).—Samples of grass and clover seed found on sale in the State have been examined and a partial report made in Bulletin No. 59. It was found that on the average one-half of the seeds in the samples examined were worthless. A series of articles, illustrating the value of certain forage plants, in order to encourage diversification of our crops, and for the purpose of increasing home products, has been commenced; the first installment appeared in the Station Bulletin No. 60.

The botanical work also includes the study of grasses and clovers adapted to this climate, forty-six varieties of which are now under cultivation on the farm,

Meteorological work (pp. 12, 13).—The State weather service co-operates with the United States Signal Service. Besides the usual operations of the State weather service, the Station issued during the growing season of 1888 a Weekly Weather Crop Bulletin, embodying the reports of nearly fifty reporters in all parts of the State. These bulletins have proven very acceptable, many of the State papers publishing these reports entire. In addition, they were much appreciated in this country and abroad, owing to their bearing on the cotton and tobacco crops.

By special arrangement with the Chief Signal Officer, we can loan sets of instruments for the use of observing stations, provided bond is given for their safe keeping. It is hoped in this way, when we can lay the advantages of having a well-kept record of the weather before the public-spirited people of enterprising towns, that many additional co-operating observers may be procured. We expect, too, to increase and revise the number of localities displaying flags, showing weather indications, cold-wave and frost warnings.

The collection of meteorological data in portions of the State is expected to aid, by a thorough knowledge of the local climatic conditions, in extending useful crops of other localities, States, and foreign countries to portions of the State.

Publications.—As a rule, publications are embraced in reports and bulletins of the Station, though occasionally separate pamphlets are issued. The following is a list for the year 1888:

	Number.
Report of North Carolina Weather Service for 1887, 37 pages.....	500
Composts and Ingredients Composing them, 24 pages	1,000
Report of Station for 1887, 225 pages	6,500
Station Bulletin No. 57	7,600
Station Bulletin No. 58.....	7,600
Station Bulletin No. 59.....	7,600
Station Bulletin No. 60.....	7,600
Report of Station for 1888.	

Previous to July, 1888, contributions from the Station were inserted in the columns of the Bulletin of the Department of Agriculture, but since that time a separate bulletin of the Station is published, in accordance with the requirements of the Hatch act.

SOUTH CAROLINA.

South Carolina Agricultural Experiment Stations.

Department of the University of South Carolina.

Location, Columbia. Director, John M. McBryde, Ph. D., LL. D.

FIRST ANNUAL REPORT, 1888.

PART I.

[Part II not yet issued.]

HISTORY AND ORGANIZATION (pp. 5-10).

When the South Carolina College was re-opened, in October, 1882, about 20 acres of land, belonging to the institution, were set apart for the purposes of agricultural experimentation. Numerous field tests of varieties of cotton, corn, small grain, grasses, fertilizers, etc., were begun under the direction of the Professor of Agriculture, and annually repeated down to 1888.

The results of the work of the earlier years of the series were given to the public in two reports, the first covering the operations of 1883, 1884, and 1885, the second those of 1886.)

The report contains the acts of the legislature relating to the Station, and an account of its organization and equipment.

The Station was established in January, 1888, by the trustees of the University, under the act of Congress of March 2, 1887, and the act of the legislature passed in December, 1887, and was consolidated with the previously established State Station in March, 1888.

Under the agreement then made by the trustees of the University and the State Board of Agriculture the Stations have three farms, situated in different agricultural belts of the State, a centrally located scientific staff, and an annual income of \$20,000; \$15,000 from the Hatch fund and \$5,000 from the State Department of Agriculture. This sum has been divided into two equal parts; the one for field experiments on the farms, and the other for salaries of the staff, scientific investigations, analyses, publication of bulletins and reports, office expenses, etc. The first half is equally divided among the three farms.

The upper farm, at Spartanburg, contains about 300 acres of land; the middle, or Columbia farm, 120 acres; and the lower, or Darlington farm, 227 acres. All three have the necessary buildings, including cottages for superintendents; large barns, with basements for stock, silos, etc.; scale and engine houses; laborers' cottages, etc.; working stock and machinery (engines, gins, presses, mills, ensilage cutters, thrashing machines, mowers, etc.).

The office of the director and laboratories of the members of the scientific staff are located in Science Hall of the University at Columbia.

REPORT OF BOTANIST AND ENTOMOLOGIST, G. F. ATKINSON, PH. B. (pp. 11-57).

I. *Botanical notes* (pp. 15-19).—Notes on club root of cabbage (*Plasmodiophora brassicae*, Woronin). This disease has been very prevalent in some places of eastern North Carolina for several years, and has

caused serious injury to the crops of the market gardeners in that region.

(1) *Empusa lampyridarum*, Thaxter.—During 1886–87 a wide-spread and deadly epidemic occurred among beetles of the species *Chauliognathus pennsylvanicus*. This disease was caused by the *Empusa lampyridarum*.

(2) *Empusa grylli*, Fresenius.

An epidemic was in progress among grasshoppers, of the genus *Tomonotus*, near Columbia, S. C., in the autumn of 1888. I caught one individual a short time before its death. The disease had so far progressed that the abdomen of the grasshopper was already putrid. A slight jar of my hand caused the abdomen of the insect to drop off close at the union with the thorax. The grasshopper lived an hour in this condition. Upon examination a few hours afterwards I found the *resting spores* of the fungus in the body of the grasshopper.

(3) *Isariasphecophila*.—A specimen of this species was taken at Chapel Hill, N. C., in May, 1888.

II. *Entomological notes* (pp. 19–57).

(a) *Some South Carolina insects* (pp. 19–53).

(1) The Chinch Bug (*Blissus leucopterus*, Say).—The notes contain an account of the successful application of the kerosene emulsion recommended by Professor Riley, of the Department of Agriculture, to destroy these insects.

(2) Harlequin Cabbage Bug (*Murgantia histrionica*, Hahn).

(3) The Squash Bug (*Anasa tristis*, Degeer).

(4) Armored Scale of the Fig (*Mytilaspis*, n. sp.).—This insect was first noticed in July, 1888, at Columbia.

The scale infests the stem, leaves, and fruit. In July the fruit seemed to be suffering more than the other portions of the tree. At this time only one shrub seemed to be badly infested, and they were slowly spreading to others in the yard. On the affected shrub all of the fruit, two or three dozen specimens, was nearly covered with the minute pale-colored scales. The injury seemed to check the growth of the cuticle of the fig, while the pulpy inner portion continued to grow in the more mature ones, so that eventually they cracked and the rich pulp and seeds were partially everted from several fissures. The younger fruits remained intact, and in the autumn were black and shriveled, about the size of a medium grape, and still clinging to the tree.

In autumn the insect was found in large numbers in Columbia and several other places.

(5) Cotton Worm (*Aletia xyliana*, Say), and the Cotton-plant Louse.

Captain Thomas, of Wedgefield, S. C., uses an interesting apparatus [made in accordance with the directions given in the fourth report of the U. S. Entomological Commission] for spraying liquid mixtures of Paris green on his cotton. It consists of a barrel pump with a transverse tube, having T arms, which reach down between the rows. One of these arms reaches down in every space, so that each row is sprayed from two sides. The T arms reach nearly to the ground. The force of the spray driving against the leaves turns them up so that the under side of the leaves is wetted. Perhaps a very slight upward slant could be given the nozzle, so that the underspraying would be quite effectual. He considers this better than the V-shaped arm, which drags on the ground, used by some, as there is less trouble in turning at the ends of the rows.

Capt. J. A. Peterkin, of Fort Motte, uses a frame, which he can regulate as to height, behind the wagon. This sweeps along on the cotton and bends it down at the same time that the spray is applied from above. He claims that to a large extent the leaves are undersprayed by this contrivance.

- (6) Red Rust Mite (*Tetranychus telarius*, Linn.).
- (7) The Fall Web Worm (*Hyphantria cunea*, Drury).
- (8) The Apple Tree Tent-Caterpillar (*Clisiocampa americana*, Harr.).
- (9) The Codling Moth (*Carpocapsa pomonella*, Linn.).
- (10) The White-Marked Tussock Moth (*Orgyia leucostigma*, Sm. and Abb.).
- (11) The Bag Worm (*Thyridopteryx ephemeraeformis*, Haw.).
- (12) The Cabbage Butterfly (*Pieris rapæ*, Schrank).

The larvæ of this butterfly, together with those of a few moths, notably *Plusia brassicæ*, are very destructive to cabbages in the middle and eastern portion of the Carolinas.

- (13) The Tobacco Worm (*Plegethontius carolina*, Linn.).
- (14) The Peach Tree Borer (*Ægeria exitiosa*, Say).
- (15) The Grape-vine Leaf-roller (*Desmia maculalis*, Westwood).
- (16) The American Procris (*Procris americana*, Harr.).
- (17) The Grape-vine Saw-fly (*Selandria vitis*, Harr.).
- (18) Singular Adaptation in Nest-Making by an Ant* (*Crematogaster lineolata*, Say).

- (19) The Colorado Potato Beetle (*Doryphora 10-lineata*, Say).

The facts thus far collected indicate that the potato beetle entered the Carolinas from some point on the coast and then gradually proceeded to the mountains.

- (20) The Hickory-twigg Girdler (*Oncideres cingulatus*, Say).

- (21) The Cigarette Beetle (*Lasioderma serricorne*, Fab.).

During the year 1886 my attention was called to the injuries of this insect, and as its natural history had not been fully worked out, I undertook investigations leading to its determination.

NATURAL HISTORY.

Number of annual generations.—There are at least two generations each year in this latitude, though the periods of transformation do not seem to be very well marked, as variations in the length of the larval stage cause an overlapping of the broods. The extremes of variation may extend so as to make it possible that some transformations are taking place at all times of the year where the temperature of the manufactory is such as to permit the activity of the insect in some of the rooms. I have seen the beetles in the act of copulation in January, and during the periods when the majority of transformations are taking place the larvæ may be found in very different stages of development.

One of these periods occurs during the month of June. June 28 I placed beetles in the act of copulation in small vials, and added a minute quantity of prepared cigarette tobacco. In from two to three days the eggs were deposited.

Egg.—The egg is opaque, white, elongate, oval, or elliptical, .4^{mm} long by .22^{mm} in diameter; micropyles .04^{mm} long, covering one end. The number of eggs deposited by the beetles observed varied from 40 to 75. In the vials which contained a few threads of prepared cigarette tobacco the eggs were scattered, some upon the

*American Naturalist, xxi, 8, p. 770.

glass and some upon the tobacco. In vials containing bits of leaf tobacco, the eggs were laid in irregular patches between the portion of a fold. In about eleven days the egg hatches.

Length of larval stage.—The larval stage at this season averages from sixty to seventy days. Eggs which were deposited June 30 hatched July 11, and some larvæ constructed cocoons September 11. From five to seven days afterward they transform to pupæ. The larva is whitish and covered with very slender white hairs. It measures from 44^{mm} to 4½^{mm} in length.

Cocoon.—The cocoon is of a papery texture, formed of finely-comminuted material which is near at hand, cemented together with a viscid liquid. In the case of cigarettes, the larva usually leaves the cigarette and makes its cocoon against the paper package, or in some of its foldings, or in a corner of the box. In this case the cocoon is made chiefly of paper. In leaf tobacco the larva usually remains among the foldings of the leaves and constructs the cocoon from tobacco. It does not use the hairs from its body in the construction of its cocoon.

The beetle is of a brown color, and about 2¼^{mm} long. It has a habit, when disturbed, of feigning death. It is said to be nocturnal in its habits; but it is also partially diurnal, as many times I have seen them in copula, and they have frequently been observed flying about the factory during the day.

Soon after pairing the male dies, and the female does not live long after she has finished depositing her eggs.

Second annual generation.—The second period of transformation into the adult state occurs about the last of August and during the month of September. Those which I bred from eggs deposited June 30 were transforming from the middle of September to the end of the first week in October. September 28 I examined some smoking tobacco which was put up July 6. The condition of the insect was about the same as of those which I reared. This would indicate that the eggs were deposited on the tobacco at the time of its preparation for placing in packages. During the month of September, with some variations, seems to be the beginning of the second annual generation. Allowing the same time for larval development as in the case of the summer generation, the larvæ would be ready in November and December for constructing the cocoons preparatory to pupating. However, as the investigations were in progress only a little more than a year, I did not have an opportunity of studying the stages of the second generation. But I judge from the condition of things as I found them in the factory in January that the earliest of the brood would construct cocoons in the latter part of the fall or early winter, and in rooms where the temperature was favorable would pupate and transform into the adult. If the temperature of the room is too low for the functional activity of the metamorphic state, the insect would remain in the larval state during the winter. From January 11 I kept a larva in its cocoon three weeks before pupating.

The greater number of individuals of the second generation would probably pass the winter as larvæ in a torpid state, and feed during the spring sometime before pupating. It may be possible that under some conditions there are three annual generations, but the indications thus far seem to favor there being in general but two. A continuation of the investigations would be necessary to determine this point.

(22) The Orchard Scolytus (*Scolytus rugulosus*, Ratz.).

(23) Observations on the Female Form of *Phengodes laticollis*, Horn.

(24) A new injury by White Ants (*Termes flavipes*, Kollar).

These insects are popularly known as "white ants," or "wood lice." They belong to the order *Neuroptera*, and not to the *Hymenoptera*, where the true ants belong.

A new and interesting rôle, in the part played by them, was discovered by me at Columbia, S. C., in the autumn of 1888. The injury consists in mining, and, in large spots, eating off the surface of the fence posts, and loosening the boards from the posts. My attention was first attracted by noticing red clay upon the posts in situa-

tions where it occurred to me it could not have been placed without design. The ants usually ascend the posts in a crack upon one side, care being taken to build a wall of red clay along the surface of the post to cut off their passage from the outside. When a few feet from the ground they construct of clay a broad and flat shed, covering an irregular area, in some cases equal to a square foot, upon the side of the post. Protected beneath this they eat away the surface of the post to a depth of one-eighth to one-fourth inches. The injury to the post is very slight, compared to that done the boards where they cross or meet on the posts. The ants carry up earth and fill the crevices between the boards and post and then feed on the board, gnawing holes nearly through, leaving only a shell where no "batten" is nailed on, but where there is a batten, the most serious injury is done. I have found such places where the boards were completely "riddled," the nails, both of the "batten" and boards loosened, the batten, in some instances falling away, and the fence boards freed from the post. The batten is intended as a protection to the boards, but becomes, where these ants are at work, a positive injury. In the outskirts of Columbia I have found long stretches of board fence which was seriously damaged. Where injury is to be apprehended from these creatures, it would be better to dispense with the batten, as it is at best only an additional expense. Tar poured in between the post and boards soon after building the fence would probably prevent the work of the ant.

(b) *Miscellaneous notes* (pp. 53-56).

(25) Fish Moths (*Lepisma saccharina*); (26) The Plum Curculio (*Conotrachelus nenuphar*, Herbst); (27) Tortoise Beetles (*Cassida pallida*, etc.); (28) The Spotted Horn-Beetle (*Dynastes tityus*, Linn); (29) Cut-Worms; (30) The Oak Caterpillars of the genus *Anisota*.

(c) *Notes on some parasitic insects* (pp. 56, 57).

Besides those mentioned in the body of the report, the following parasitic insects have been bred: *Anomalon apicale*, *Limneria fugitiva*, *Hemiteles* sp., *Hemiteles thyridopterygis*, *Spilochalcis* sp., *Chalcis flavipes*, *Torymus* sp., *Entedon* sp., *Pteromalus* sp., *Copidosoma truncatellum*, *Apanteles* sp., *Apanteles*, sp., *Trioxys testaceipes*, *Bovista bifasciata*, *Tachina* sp., *Holcopolte* sp., *Apanteles* sp.

REPORT OF ANALYST OF SOILS, SEEDS, ETC., R. H. LOUGHRIDGE, PH. D. (pp. 58-99).

Tests of purity and vitality of seeds.

The methods adopted for these tests at this Station may be given as follows: After the sample has been thoroughly mixed, a portion, varying in weight according to the fineness of the seed, is taken for the examination.

Purity.—The weighed portion is placed in a shallow tray, and, with a pair of pincers and a pointed horn spatula, all of the coarser trash, etc., is quickly removed to one side. With the small seed a magnifying glass is brought into use, and almost one by one the impure or foreign seeds are removed, and the fine trash added to the larger. The foreign seeds are then examined also, and separated into the several kinds. Each lot is then weighed, and the percentages determined. In this way each seed passes under the eye of the examiner.

Weight and Vitality.—One hundred of those seed put aside as pure are weighed and then put to soak in water for twelve hours, when they are placed in the germinating apparatus to test their vitality.

There are a number of forms of such apparatus, each intended to furnish to the seed the necessary moisture, heat, and darkness to enable the germs to start into activity. These conditions can be supplied by placing the seed in the grooves of flat, porous tiles, which are placed in copper boxes holding a thin stratum of water, and properly covered. The tiles keep the seeds moist, but not wet, and the temperature can be easily regulated. This Station has recently been supplied with these tiles for future tests.

In the examinations of the past year the Geneva germinating apparatus was used, and was found to answer the purpose very well.

In several instances these impurities consist largely of seed of other grasses. The sample of tall meadow-grass seed had 44.5 per cent of trash alone. The seed of the grasses, from their nature, are separated from their chaff and trash in thrashing, and at the same time the chaff and empty receptacles are less easily detected than is the case with other seed. The clovers are next in the proportion of impurities.

With the improved machinery for freeing seed from impurities now at the command of the seedsmen there is no excuse for adulteration.

The average percentages of good seed of the different classes germinating, as shown in the third column, give a maximum of 100 in cotton and a minimum of 20.4 per cent for the grasses. The latter thus stand lowest in good seed and highest in impurity percentages. Hence they are lowest in percentage value (16.8).

The clovers are next in low averages, but little more than one-half of their seed proving good; the same is true of pop-corn.

The vegetable seed are rather low in vitality, six of the thirteen kinds having percentages lower than 75 of good seed, and only two of 90 or more.

The following table summarizes the results of tests:

Summary of results.

Name.	Varie- ties.	Impuri- ties.	Seed germi- nating.	Value.			Weight of 1,000 seed.	Approxi- mate seed in a pound.
				Maxi- mum.	Mini- mum.	Average value.		
VEGETABLES.								
	<i>No.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per cent.</i>	<i>Grams.</i>	<i>No.</i>
Cabbage	15	3.6	62.7	93.0	16.4	60.1	3.6	125,000
Lettuce	9	3.7	78.5	98.0	0.0	75.3	1.2	378,000
Tomato	18	0.7	86.7	98.0	58.0	86.7	2.9	153,000
Beets (in pod)	13	1.6	57.6	81.0	35.0	56.9	18.0	25,000
Pepper	7	.....	71.0	95.0	42.0	71.0	6.1	74,000
Okra	6	0.4	56.3	77.0	27.0	56.0	55.6	8,000
Onion	2	.....	79.0	92.0	66.0	79.0	3.9	117,000
Radish	2	2.8	86.0	91.0	76.0	83.5	10.5	43,000
Egg plant	2	.....	59.5	64.0	55.0	59.5	4.9	92,000
Parsnip	1	.....	90.0	.....	.....	90.0	8.6	52,000
Lentil	1	.....	63.0	.....	.....	63.0	32.9	13,700
Peas	5	.....	86.2	98.0	62.0	86.2	223.4	2,000
Beans	4	.....	93.8	100.0	86.0	93.8	471.3	1,100
FIELD CROPS.								
Corn	8	.....	87.7	97.0	80.0	87.7	262.9	1,700
Sugar corn	5	.....	90.0	98.0	77.0	90.0	215.6	2,100
Pop-corn	2	1.2	59.5	63.5	55.0	59.3	130.0	3,500
Cotton with lint	39	.....	100.0	100.0	100.0	100.0	113.0	4,000
Grasses	8	22.3	20.4	64.4	0.0	16.8	1.4	325,000
Vetch	1	22.0	78.0	.....	.....	78.0	50.6	9,000
Clovers	8	6.7	54.0	69.7	0.0	50.6	2.5	180,000

The results for the varieties of seed are given in detail in twenty-six tables in the report, together with descriptive notes.

REPORT OF CHEMIST, W. B. BURNEY, PH. D. (pp. 100-141).—The following is taken from the introduction to the chemist's report:

Of the various subjects which suggest themselves at the moment of beginning lines of investigation in a State Agricultural Experiment Station, but few seem equal in importance to that of fodders and feed stuffs, and particularly is this true in a State whose soil, in many sections, is not specially adapted to the growth of the various grain crops. A generation ago, when our soil was at its best and labor was cheap, we could afford to be indifferent to wasteful and unscientific methods; now,

with reduced productiveness of soil, increased cost and lower efficiency of labor, to make farming profitable, the full resources of our soil must be developed and its products husbanded by the practice of an intelligent and scientific economy. In no direction does this seem so much needed as in the production and manner of use of the feeding stuffs intended for our farm animals.

The report contains a reprint of the tables of the composition of American feeding stuffs, compiled by Dr. E. H. Jenkins, of the Connecticut Station, and also gives tables of analyses of feeding stuffs and their digestibility, and tables of feeding standards obtained chiefly from the German Stations, and published in the report of 1886 of the Connecticut Station.

Analyses of feeding stuffs (pp. 123-137).—The following tables give the summary of the results of the analyses made at the Station:

Table of albuminoid and non-albuminoid nitrogen in 100 parts of dry matter of the feeding stuffs.

	Total ni- trogen.	Albuminoid nitrogen.	Amide ni- trogen.	Total N. in amide form.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sweet potatoes	.72	.64	.08	11.11
Soja beans	6.27	6.11	0.16	2.55
Bermuda hay	1.56	1.45	.11	7.05
Vetch in full bloom	4.58	3.61	.97	21.18
Vetch with pods half grown	3.22	2.55	.67	20.80
Prickly comfrey	4.43	3.01	1.42	32.05
Means grass	1.98	1.554	.426	21.51
Smut grass	1.92	1.703	.217	11.30
Bermuda grass	1.217	1.117	.10	8.22
Texas millet before bloom	2.446	1.818	.628	25.67
Texas millet in full bloom	1.182	.939	.243	20.56
Cow-pea vine in full bloom	2.86	2.12	.74	25.88
Cow-pea vine, pods two-thirds grown	3.19	2.71	.48	15.05
Pea-vine roots	.87	.67	.20	23.00
Cow-pea roots, pods two-thirds grown	.94	.80	.14	14.89

Table of digestibility in 100 parts of dry matter of foregoing feeding stuffs.

	Crude pro- tein, N x 6.25.	True albu- minoids.	Undigested.	Crude albu- minoids. Digested.	True albu- minoids. Digested.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sweet potatoes	4.51	3.97	1.69	62.52	57.43
Soja beans	39.17	38.20	2.92	92.54	92.36
Bermuda hay	9.76	9.06	4.61	52.77	49.22
Vetch in full bloom	28.63	22.56	4.99	82.5	77.88
Vetch in pods half grown	20.12	15.94	3.56	82.31	77.67
Prickly comfrey	27.69	18.81	14.00	49.44	25.57
Means grass in full bloom	12.33	9.71	3.00	75.67	69.10
Smut grass in full bloom	12.07	10.64	3.93	67.44	63.07
Bermuda grass in full bloom	7.61	6.98	2.92	61.63	58.17
Texas millet before bloom	15.31	11.36	3.79	75.18	66.64
Texas millet in full bloom	7.36	5.87	2.69	63.45	54.17

The report also contains tables giving details of these analyses. We quote those for Bermuda hay (pp. 123, 124).

Bermuda hay, field cured (Cynodon dactylon), grown on the station farm at Columbia, S. C.

	Per cent.	Pounds per ton of 2,000 pounds.
Moisture at 100°	10.36	207.2
Dry matter.....	89.64	1,792.8
Total	100.00	2,000.0
ANALYSIS OF DRY MATTER.		
Ash.....	9.59	191.8
Crude protein.....	9.76	195.2
Crude fat	2.44	48.8
Crude fiber	24.14	483.0
Non-nitrogenous extract.....	54.06	1,081.2
True albuminoids.....	100.00 9.06	2,000.0 181.2

Bermuda grass, from the station farm at Columbia, collected when in bloom, June 16, 1888.

	Per cent.	Pounds per ton of 2,000 pounds.
Moisture at 100° C.....	71.70	1,434.0
Dry matter	28.30	566.0
	100.00	2,000.0
ANALYSIS OF DRY MATTER.		
Ash.....	7.07	141.4
Crude protein.....	7.61	152.2
Crude fat	3.36	67.2
Crude fiber	20.79	415.8
Nitrogen-free extract	61.17	1,223.4
True albuminoids.....	100.00 6.98	2,000.0 139.6

This is among our best known and most valuable pasture grasses. It produces well, and is quite nutritious, as shown by the analysis. It withstands heat and drought admirably, and consequently flourishes on sandy soils, where it remains green and growing after other grasses are parched by the summer's sun. It is a perennial grass, and as it propagates itself by offshoots from the joints, a good stand soon covers the ground. Though often regarded as a pest, because somewhat difficult to exterminate, it is of the greatest value in the South, especially for sandy soils. In favorable seasons, several cuttings can be made, and a good hay obtained.

If the money and labor expended in saving corn-fodder were devoted to the fertilization and care of a field of Bermuda grass by every farmer in the State, it is safe to predict that it would be speedily followed by some timely and salutary changes in present methods.

The report also contains tables giving the result of analyses of the following fertilizing materials: Long-leaf pine straw, short-leaf pine straw, cow-pea meal, cotton-seed meal, cotton-seed-hull ashes, kainit, marl, muck, floats, phosphate slag.

TENNESSEE.

Tennessee Agricultural Experiment Station.

Department of the University of Tennessee.

Location, Knoxville.

Director, Charles W. Dabney, jr., Ph. D.

FIRST ANNUAL REPORT, 1888.

REPORT OF DIRECTOR (pp. 3-11).—The report contains an account of the organization and equipment of the Station. The Station is organized in four divisions, as follows:

- I. *The Division of Field and Feeding Experiments.*
- II. *The Division of Chemistry.*
- III. *The Division of Botany and Horticulture.*
- IV. *The Division of Entomology.*

We found it somewhat difficult to get farmers interested, at first, in the work proposed to be done here for them, but by attending farmers' meetings, and advertising the work of the Experiment Station through the columns of newspapers and supplements to newspapers, we are succeeding now in getting up a large list of names and post-offices of farmers with whom we shall correspond and to whom bulletins and reports will be regularly mailed.

Three bulletins have been published, one in April, one in July, and one in October. A copy of each accompanies this report.

REPORT OF AGRICULTURIST, C. S. PLUMB, B. S. (pp. 12, 13). *Horticultural field-work.*—The following is a list of the fruits planted, and number of varieties of each:

Apples	50	Cherries	25	Gooseberries	6
Pears (standard)	28	Plums	32	Blackberries	6
Pears (dwarf)	22	Figs	3	Raspberries	14
Peaches	42	Almonds	2		
Nectarines	3	Quinces	4	Total	259
Apricots	25	Currants	12		

Some twenty-five varieties of strawberries and a few of vegetables were planted on the station farm. Field experiments with grasses, clovers, sorghum, and wheat, and feeding experiments with steers and cows have been begun, but no results are published. Fertilizer experiments are also in progress in the greenhouse. Experiments have been made on germination of seed corn and dehorning of cattle.

REPORT OF CHEMIST, W. E. STONE, PH. D. (pp. 13-15).—This report contains an account of the laboratory and apparatus of this department.

The report of work performed covers only the month of December. The relation of the Station to the State fertilizer inspection requires the analysis of samples of commercial fertilizers sold within the State, at this place. The samples which had accumulated at the opening of the laboratory engaged my immediate attention, and up to date twelve have been analyzed. As soon as this work has been completed, plans have been prepared for a systematic chemical investigation of some of the staple crops of the State, and the study of certain questions connected with dairying. These, with the general investigation of forage crops, and the variety of incidental work constantly arising, will, it is thought, fully occupy the attention of this division during the coming year.

REPORT OF BOTANIST AND HORTICULTURIST, F. L. SCRIBNER, B. S. (pp. 15-17).—This report gives an account of the laboratory and equipment of this department.

Arrangements are now being made for investigating the grasses and forage plants of the State, with the view of determining what they are; their distribution and prevalence; their value for hay or for grazing; and the diseases with which they are affected. In conjunction with this work, it is contemplated to introduce native species of promise from other parts of the country, to test their adaptability to our soil and climate.

If found possible to do so, the work of the division the coming season will also embrace the investigation of some one or more of the fungus diseases which so seriously affect many of our cultivated crops. For the investigation of the grasses, and for doing a limited amount of work on the injurious fungi, the division is well equipped.

REPORT OF ENTOMOLOGIST, H. E. SUMMERS, B. S. (p. 17).—The report contains an account of the laboratory and equipment of this department.

ACTION OF THE BOARD OF TRUSTEES OF THE UNIVERSITY (pp. 19, 20).—The action was taken June 8, 1882, for the establishment of the Station, and provides a plan for its organization.

ACT OF THE LEGISLATURE (p. 23), passed March 28, 1887, assenting to the act of Congress of March 2, 1887.

BULLETIN No. 1, APRIL, 1888.

Article I, *History and Reorganization, by the Director* (pp. 1-5).

The Agricultural Experiment Station of the University of Tennessee grew out of its School of Agriculture, Horticulture, and Botany. The experimental work of this school was inaugurated by Prof. J. M. McBryde, who was at its head from June, 1879, to June, 1882. Three reports, 150 to 200 pages each, on experimental work, for the most part field and feeding experiments, were published during this period.

The Station never enjoyed any fixed or settled income until the present year. The trustees of the University voted it such funds as they could spare from time to time from the general treasury. The amount from this source, not including salaries, which the officers received as professors, was necessarily very limited. In spite of these difficulties considerable and valuable work was done, chiefly field and feeding experiments.

From 1883-87 the Station published a number of bulletins and reports.

Article II, *Dehorning Cattle, by Charles S. Plumb, B. S.* (pp. 5-16). (Illustrated.) The following are the conclusions drawn from the experiments made at this Station:

(1) The most desirable method of fastening an animal for dehorning, so as to keep it satisfactorily quiet, is to cast it, bind the feet firmly together, and hold the head in a halter, close to the ground, either by the hands, or by placing a plank across the neck. To then remove the horn uppermost, and by means of a rope of sufficient length, fastened where the feet come together, to turn the animal upon the other side, and remove the remaining horn.

(2) For removing the horns, an ordinary meat saw, with a set screw in the end of the blade furthest from the handle that will enable the blade to be tightened, but not to turn from side to side, is perfectly satisfactory. A strong running-noose rope

halter, and about 20 feet of five-eighths and 10 feet of three-eighths inch rope are also necessary.

(3) The horns should be removed as close to the head as possible, without cutting the skull proper. It is best to cut down from one-fourth to one-half inch of flesh, at the base of the horn. The sawing should be done rapidly, and with long sweeps of the arm, if possible.

(4) Animals one and two years of age appear to suffer considerably in dehorning. The painful effects decrease with increase of age, so that an animal ten years old may suffer but very little. This is owing to the layer of flesh surrounding the base of the horn, which is much thicker in young than old animals. Dehorning causes an abnormal increase of pulsation and temperature, which extends over several days. The appetite is also affected during the twenty-four hours succeeding the operation.

(5) Dehorning is more especially to be recommended for those animals that are of vicious temperament, that are what are termed "masters"; to be applied to bulls, and to beef animals that are to be kept quiet and closely stabled or shipped.

(6) From evidence quoted from other sources, it appears that dehorning is not necessarily a cruel practice, but may be conducted to promote ends that are both humane and desirable in live-stock breeding.

BULLETIN No. 2, JULY, 1888.

Article I, *The Experiment Station, Building, and Laboratories, by the Director* (pp. 17-20). (Illustrated.) An account of the excellent station building, which was completed in November, 1888.

Article II, *Germination of Seed-corn, by C. S. Plumb, B. S.* (pp. 20-25).

On December 1, 1887, circulars were sent to farmers in Tennessee whose addresses could be obtained, requesting them to favor the University as follows: To send central sections, about an inch in length, from about five ears of corn, such as would be used for seed the next year, either from crib, field, or wherever the seed-corn might be stored. Particulars were also requested concerning the location of the corn-field, soil upon which grown, method of harvesting, preservation, etc.

The plan was to secure seed from as many persons as possible, and germinate. Every year many acres of corn have to be replanted, owing to improper methods of preserving seed. It was thought that by securing seed from various parties and germinating we could get a fair general idea, from information furnished, of the best practical plan in use of keeping corn over winter for spring planting.

Seed was received from sixteen different counties and seventeen persons.

The article contains extracts from the letters of parties sending seed, and tables giving in detail the results of the tests made. The following are the conclusions drawn:

(1) That, so far as sample seed-corn from sixteen different counties in Tennessee give a fair average of the condition of the seed of the State, the vitality of that produced by the crop of 1887 is high.

(2) The evidence is in favor of storing ear-corn without the husk for seed purposes, though the results coming from the two methods differ very slightly and to no practical extent.

(3) That it is customary for farmers to preserve their seed-corn in as dry condition as possible under shelter, preferably in a high airy place.

Article III, *Analyses of Commercial Fertilizers* (pp. 25-27). The article contains tables showing the results of the twenty analyses made in the season of 1887-88.

BULLETIN No. 3, OCTOBER, 1888.

Preliminary Report on the Weeds of the Farm, by F. Lamson Scribner, B. S., and C. L. Newman, B. S. (pp. 29-52). The bulletin contains a list of the weeds found on the university farm, with a description of each variety, and illustrations of some of the more common species.

TEXAS.

Texas Agricultural Experiment Station.

Department of Agricultural and Mechanical College of Texas.

Location, College Station.

Director, F. A. Gulley, M. Sc.

THIRD ANNUAL REPORT, 1888.

REPORT OF DIRECTOR (pp. 9-16).—After consultation with individuals and farmers' associations throughout the State, the following lines of work were undertaken by this Station:

- (1) A study of the most practicable and economical method of feeding cattle for beef and for the dairy.
- (2) A study of the disease of the cotton plant known as "Cotton Blight" or "Root Rot."
- (3) Testing varieties of fruits to ascertain what kinds are best adapted to the State, and at the same time help to designate the varieties by their proper names.
- (4) Test grasses and forage plants, adaptability to localities, and value for grazing and feeding.
- (5) Effect of barn-yard manure and commercial fertilizers for certain crops.
- (6) Value of tile drainage for farm and garden crops.
- (7) Disinfection and inoculation of cattle to protect from "Texas fever."

An agreement has been made with the Missouri Station for joint experiments regarding "Texas fever." The report contains the full text of this agreement. The subjects to be studied under this arrangement are thus stated:

- (1) Determine the places in the soils, etc., whence the virus of Texas cattle fever comes.
- (2) Determine the parts in Southern cattle and their products where the virus exists.
- (3) Determine the accessory sources, such as ticks, cured and uncured hay, and other food, if there be any (such sources).
- (4) Determine the period of incubation of the disease in Northern cattle.
- (5) Determine the duration of infection in Southern cattle.
- (6) Make researches with a view to disinfecting cattle alive before leaving the South for the North.
- (7) Determine the best and cheapest modes for disinfection of cars, stock, yards, etc.
- (8) Make researches with a view to establish immunity from Texas fever in Northern cattle by vaccination or otherwise when shipped South.
- (9) Determine whether horses and other animals are capable of transferring Texas fever germs.
- (10) Determine how long in the North the Texas fever virus exists in dangerous activity.
- (11) Determine whether under any condition Northern cattle can cause infection of other Northern stock.
- (12) Determine if Southern stock calves acquire immunity from Texas fever by inoculation from the mother before birth, or only afterwards.

BULLETINS.

Four bulletins have been issued since the organization of the Station: No. 1. Plan of Organization; No. 2, Corn, Cob, and Shuck Feeding; Analyses of Fertilizers, Feed Stuffs, and Ores; No. 3, Grasses; No. 4, Root Rot of Cotton, or Cotton Blight.

REPORT OF AGRICULTURIST, GEO. W. CURTIS, M. A. S. (pp. 17-20).

(1) *Experiments with Johnson grass*.—The experiments with this grass, which were begun in 1884 on the college land, indicate that it requires a rich soil.

(2) *Experiments with fertilizers*.—For several years experiments with fertilizers have been undertaken at the College, and their results reported in the college bulletins.

(3) *Feeding experiments*.—(a) To test the comparative value of corn fed whole (in the shuck) to hogs, and the same ground coarsely (corn, cob, and shuck together). It was found that the whole corn gave much better results. (b) With six steers, in two lots of three each, continued for seventy days.

To one lot was given a certain amount of grits (coarsely ground or crushed corn) and to the other an amount of shelled corn, cob, and shuck ground together, which contained an amount of shelled corn equal to that fed lot No. 1.

The results are reported in Bulletin No. 2, from which the following summary is taken:

Considering the foregoing, in brief, it is found that the lot of steers fed on "chops" alone made a gain in seventy days of 465 pounds, an average gain of 2.21 pounds per day and head, and requiring 4.008 pounds of feed to produce one pound of gain.

The lot fed on an equal amount of "chops," with the cob and shuck added, as already noted, made a gain in seventy days of 480½ pounds, an average of 2.29 pounds per day and head, requiring but 3.833 pounds of "chops," with cob and shuck added, to produce one pound of gain. The excess, although slight, shows in favor of a certain value in the cob and shuck, but it is a question as to whether the gain observed will pay for the extra time and power required to grind corn, cob, and shuck together, at least when the small sweep mills are used.

REPORT OF CHEMIST, H. H. HARRINGTON, M. SC. (pp. 21-34).—The report contains details of analyses of fertilizers, minerals, soils, food stuffs, grasses, and mineral waters.

Analysis of prickly pear cactus (calculated to the freshly gathered plant).

	Per cent.
Water.....	88.85
Dry matter.....	11.15
Crude ash.....	1.94
Crude fats.....	0.39
Crude cellulose.....	1.27
Albuminoids.....	1.16
Nitrogen-free extract.....	6.39
Nutritive ratio.....	1 : 8.61

This plant grows extensively over a large portion of the State, and for many years ranchmen have fed it to their cattle.

With a more concentrated feed, as cotton or cotton-seed meal, it is said to possess excellent fattening qualities. The cactus, after being cut out, is sometimes singed until the small sharp thorns with which the plant is covered are destroyed, and is then fed to the animal. At other times the cactus is passed through a cutting ma-

chine, and the coarsely-chopped pieces, or even the whole cactus, are seamed until much reduced in bulk, and then fed to the stock. All these modes of treatment have the same ultimate object—to destroy somewhat the small sharp stickers on the cactus. Cotton seed, cactus, and sorghum fodder make an exceedingly rich feed, on which cattle fatten very rapidly. One great claim that cactus presents as a feeding stuff is the fact that it grows where nothing else will grow during a drought. At such a time the large percentage of water which it contains may be one of its chief values. Again, the cost of collecting is nominal, and in this way it strongly recommends itself to the stockman. From its analysis I should say it is not quite so valuable as carrots or turnips, but the comparison is more favorable than I expected it would be. I regard it as an important economic growth in the western part of the State.

Analysis of mesquite beans (No. 396).

	Per cent.
Moisture.....	5.96
Dry matter.....	94.04
Crude ash.....	5.20
Crude fat.....	5.12
Crude cellulose.....	32.53
Albuminoids	14.03
Nitrogen-free extract.....	37.13
Nutritive ratio	1 : 5.8

The above is the analysis of the entire bean pod. The mesquite bean is another valuable feed-stuff in Texas. It is the fruit of the mesquite tree (*Prosopis juliflora*) that is found over a large portion of the State. The tree is low and branching, rarely attaining a size above that of the average peach tree. The branches are pliant, and can be easily bent down by cattle. Feeding in this way the cattle save the stockman from collecting a feed-stuff that compares very favorably with oats and corn.

The amount of cellulose, or woody fiber, is very much larger in the bean, and the amount of nitrogen-free extract, considerably smaller; but the albuminoids and fats compare very well indeed. The bean pod is 4 to 8 inches in length, and grows in bunches from six to eight pods to the bunch. The beans are not generally gathered, but sometimes they are, by the wagon-load. They then make an excellent feed for cattle, horses, and cows.

REPORT OF HORTICULTURIST, T. L. BRUNK, B. Sc. (pp. 35-44).—The work has been largely that of setting out experimental and test orchards of the many different fruits, and a vineyard of sixty-eight varieties of grapes. In order to test varieties on different typical soils, orchards will probably be set out on the several State farms during the coming season. Such an orchard has been set out at Prairie View, where the soil is of an entirely different character from that at the Station.

The report contains some notes on the varieties of grapes which can be profitably grown in Texas.

(1) *Peach and plum rust*.—Bordeaux mixture was successfully used on plum trees.

(2) *Experiments with fertilizers on sweet potatoes*.—The report contains a tabular statement of the results of a few experiments with different fertilizers.

(3) *Tests of forage plants*.

Last spring fifty-three species of forage plants were placed in test plats, and the results of their growth and several observations and notes formed the subject-matter

for Bulletin No. 3. * * * Most of the introduced perennial grasses from Europe were total failures. All the native grasses and most of the leguminous plants were quite successful, except the clovers proper, which did not survive the drought.

Of the perennial species tried here, the following can be said to have survived the drought satisfactorily, and to have produced a profitable growth: Louisiana grass (*Paspalum platycaule*); *Paspalum dilatatum*; Bermuda grass (*Cynodon dactylon*); Johnson grass (*Sorghum halepense*); reed Canary grass (*Phalaris arundinacea*).

Of the so-called clovers the following thrived: Alfalfa or Brazilian clover (*Medicago sativa*); Japan clover (*Lespedeza striata*); sweet clover, Bokhara clover (*Melilotus alba*); bird's-foot clover (*Lotus corniculatus*).

Of the annuals good for hay or fodder plants are the following: Millo maize (*Sorghum vulgare*); Kaffir corn (*Sorghum kaffrorum*); teosinte (*Euchlœna luxurians*); pearl or cat-tail millet (*Penicillaria spicata*); large Canary grass (*Phalaris intermedia*, var. *angustata*); small Canary grass (*Phalaris intermedia*); Hungarian millet or Italian millet (*Setaria italica*); rescue grass (*Bromus unioloides*).

REPORT OF VETERINARIAN, M. FRANCIS, D. V. M. (pp. 45-49).—This report contains notes on the screw-worm (*Lucilia macellaria*, Fab.).

ROOT ROT OF COTTON, OR "COTTON BLIGHT," L. H. PAMMEL, Shaw School of Botany, St. Louis, Mo. (pp. 50-65).—This is a preliminary report, and deals largely with different theories respecting the nature of this disease, and its treatment.

FERTILIZER EXPERIMENT, J. H. CARSON AND F. A. GULLEY, M. Sc. (pp. 66-68).—This is a preliminary report on the first of a series of experiments to test the effects of fertilizers with ensilage corn.

STOCK FEEDING, H. H. HARRINGTON, M. Sc. (pp. 69-74).—Explanations of the ordinary tables of feeding standards and food stuffs.

REPORT OF METEOROLOGIST, J. H. KINEALY, D. E. (p. 75).

VERMONT.

Vermont State Agricultural Experiment Station.

Department of University of Vermont.

Location, Burlington.

Director, W. W. Cooke, M. A.

SECOND ANNUAL REPORT, 1888.

REPORT OF DIRECTOR.—The report contains an account of the organization, location, equipment, and lines of work of the Station.

The Experiment Station owes its existence to an act passed by the Legislature in the fall of 1886, in which it says, "There is hereby established a State Agricultural Experiment Station, in connection with, and under the control of the University of Vermont and State Agricultural College." That Legislature also made a grant of \$3,500 a year for carrying on the work of the Station, and it was conducted for a little over a year on this appropriation.

Fruits.—The most important line of investigation with respect to fruit in this State is to find varieties that will withstand the severity of our winters, produce fruit of good quality, and ripen it before cold weather. The most hopeful field for trial seems to lie in the Russian fruits, which endure in their native country much severer weather than we experience here. In accordance with this plan, the Station secured and set out many of the most promising Russian fruits, and some of the long known standard varieties with them for comparison. Of fruit trees, two of each kind were planted; grapes, two of a kind; bush fruits, ten of a kind, and strawberries, fifty of

each kind. The following number of varieties of each kind of fruits have been planted: 30 apples, 16 pears, 16 plums, 16 cherries, 50 grapes, 15 currants, 7 gooseberries, 12 blackberries, 31 raspberries, 2 dew-berries, 54 strawberries.

Vegetables.—The work of the Station in this line has thus far been confined to the testing of varieties.

Forage crops.—As the pastures of Vermont grow poorer and the midsummer droughts are more severely felt, the need of forage crops becomes more and more pronounced. Some crop which shall produce, with a small amount of hand labor, a large amount of fodder during midsummer and early fall has become an urgent necessity, and the Station has grown quite a number of different plants which gave more or less promise of yielding the desired result. Among them may be mentioned Brazilian flour corn, barley, teosinte, dhoura, vetches, Hungarian grass, English perennial rye, prickly comfrey, Japanese buckwheat, alfalfa, and many varieties of ensilage corn. Of these the most promising are barley, Japanese buckwheat, some varieties of the ensilage corn, and prickly comfrey. Alfalfa was tried on over thirty farms throughout the State, and although it did well the first summer and was looking finely when the snow came, in most cases it winter killed, and the almost unanimous opinion of those who tried it was that it is not adapted to our climate. Some varieties of the ensilage corn yielded wonderful returns. The "red cob" produced at the rate of 30 tons to the acre, with perfect ears a foot long. Analysis shows that in case of several of these varieties of large corn they not only produced an immense weight, but that weight contains a large amount of good feeding material. Judging from the results of this season's work, prickly comfrey is worthy of an extended trial.

Methods of planting.—Experiments designed to find out proper methods of planting were tried with both corn and potatoes. With corn the experiments were designed to test the different ways in which planting may be done with the Eclipse corn-planter. The rows were each 3 feet apart and the corn was planted at distances in the row of 36, 24, 12, and 6 inches apart. The highest yields were obtained from the 36-inch and the 6-inch planting. The gross weight of the product of the 6-inch was more than that from the 36-inch, but the yield of ear corn at the greater distance apart was much more than that from the less.

Fourteen different ways of cutting and planting potatoes were tried, the results of which were printed in Bulletin No. 13 of the Station, from which it appears that mulching when 4 inches high produced a considerably larger yield than any other method, and the smallest yield was obtained by dividing.

Tests of fertilizers.—During the past summer the Station made extended experiments in the use of these insoluble phosphates on corn, potatoes, and grass. The experiment with corn was tried on a very light sandy soil near Essex Junction, and the same repeated on heavy clayey soil at the University. On the former land the soluble phosphates gave much better returns than the insoluble, as would naturally be expected, since the sand furnishes but little of the moisture and vegetable acids necessary to render soluble these phosphates. On the heavy moist clay ground the insoluble phosphates gave just about the same weight of crop as the soluble, but it was noticed that the proportion of grain was greater and the corn ripened earlier where the soluble phosphates were used.

On potatoes almost the opposite was observed, and the best results were obtained by using an insoluble phosphate, made by reducing to a fine powder the slag from some of the English iron-works.

In a trial at the farm, in very carefully constructed boxes, the soil of which had been made as nearly uniform as possible, it was found that this same phosphate slag had a great influence on the growth of the corn, producing nearly if not quite as much yield per dollar of cost as the soluble forms, and undoubtedly leaving a much larger amount of phosphate in the soil for the use of future crops.

Laboratory work.—Since March 1 the Station has analyzed the following number of samples of the various materials: 138 licensed fertilizers, 29 unlicensed fertilizers, 92 fodders, 10 waters, 2 ashes, 8 mucks, 1 ground limestone, 1 dried fish scrap, 2 bone-

meals, 2 potash salts, 112 whole milks, 50 skim-milks, 50 buttermilks, 15 creams, 17 butters, 5 insecticides, 2 miscellaneous.

Tests of creameries.—During the warmer months of last summer the Station made quite extended tests of the work of several creameries in various parts of the State. Cream well ripened and well stirred, so as to be evenly ripened, ought to leave in the buttermilk less than one-half of 1 per cent, and at the Experiment Station we have repeatedly found less than one-fourth per cent of fat left in the buttermilk; that is, it would take 400 pounds of such buttermilk to make a pound of butter. On the contrary, in some of the creameries we have found this per cent very largely increased, even up to a dozen or more pounds of butter in 400 pounds of buttermilk. The total loss of butter of the creameries is larger than most people suppose. There was hardly a creamery tested at which the loss was not at least 1 pound of butter to every 10 that was saved; that is, if all the fat in the milk had been saved the creameries would make 11 pounds of butter for each 10 that they now produce.

Apple pomace.—It has often been claimed that apple pomace has no feeding value and the practice of almost all the cider-mills in throwing away the pomace shows that this belief in its worthlessness is widespread. Chemical analysis has always said that there was considerable feeding material in pomace, and the Station undertook to find out whether this was so. As the pomace from the mill would not keep it was determined to put it into the silo and see whether, by exclusion of air, it could be preserved; the result was a perfect success. About 6 tons of pomace were put into a small silo 6 feet square; each load was leveled and tramped down firmly, and when the last load was in the whole was allowed to stand and heat to about 90° F.; it was then covered and weighted with stones, about 50 pounds to the square foot. The heat decreased at once, and when the cover was removed a month later the pomace was found in a state of perfect preservation, and remained so during all the weeks that we were feeding it. The milch cows like it exceedingly; when there is any other in their mangers they take it in preference to any other fodder we can give them and eat it all before beginning on hay or corn fodder, which was usually given with it. There was no decrease in the milk flow, as has often been claimed to be the result of feeding apple or pomace, and we probably get from it the full feeding value, as indicated by chemical analysis. We fed 10 pounds a day, in two feeds of 5 pounds each, night and morning.

WISCONSIN.

Agricultural Experiment Station of the University of Wisconsin.

Department of the University of Wisconsin.

Location, Madison.

Director, W. A. Henry, B. Agr.

FIFTH ANNUAL REPORT FOR THE YEAR ENDING JUNE 30, 1888.

REPORT OF DIRECTOR (pp. 1-4).—The report shows the increasing favor with which the work of the Station is regarded by farmers.

It may be stated, without boasting, that many of our farmers express a high appreciation of the value of the station work and that the relation between this class and the Station is growing more and more intimate. When the writer came to the University in 1880 not more than one letter a week on an average came to what was then styled the agricultural department. The correspondence has gradually increased, until during the last year 1,785 pages of letter-book were required for copying the letters sent out in that time. When it is understood that many of these letters contained inquiries upon agricultural topics that required investigation and reading up before they could be answered, the magnitude of this one line of the Station's efforts will be appreciated. Questions about forage plants of all kinds, weeds, insects, cattle feeding, and land drainage are very numerous, and receive as careful attention as our knowledge and ability to give assistance permits. In addition to the correspondence

over fifty newspaper communications have been written, largely in answer to inquiries sent to the Station or regarding its work. This and the greater part of the correspondence has fallen to the director, who has also assisted the superintendent of farmers' institutes, so far as his duties would permit, in such meetings as were held previous to the beginning of the year, after which instruction to the short-course students required all his spare time at the University.

The Station, in planning its work, has never attempted to cover but a very small portion of the field of agriculture, considering that it was far better to do a few things reasonably well than to attempt a great deal with the probability of accomplishing but little. We have endeavored to prosecute lines of investigation which seemed the most important and to offer large prospects of usefulness. To this end the feeding of live stock and the dairy industry have occupied most of our time.

During the year four bulletins have been issued: No. 12, October, 1887, The Oil Test for Cream; No. 13, February, 1888, Report on Crops, the Station Vineyard; No. 14, April, 1888, Land Plaster; No. 15, May, 1888, Ensilage *vs.* Fodder Corn for Milk Production.

ENSILAGE VERSUS DRY FODDER-CORN FOR PRODUCING MILK AND BUTTER, W. A. HENRY, B. AGR. (pp. 5-28).

In the spring of 1887 considerable ensilage corn was planted upon the experimental farm, of the varieties and in the manner described further on. The season of 1887 was the driest one for years in this section, the hay crop being an almost complete failure. Our corn planted for ensilage, however, was very satisfactory in growth though about a month ahead of ordinary seasons in ripening.

To test the yield and value of varieties for silo purposes, our ensilage corn in 1887 was planted in strips of twelve rows each. First came twelve rows of Pride of the North, a yellow dent variety; next twelve rows of large sweet corn, and next to this twelve rows of Burrill and Whitman ensilage corn. The varieties were repeated in this manner until the whole field was planted. The yellow dent and sweet corn varieties had the grains about 4 to 6 inches apart in the row, while the B. and W. was planted about 6 to 8 inches apart in the row; the rows were 3 feet 10 inches apart.

Yield of ensilage fodder corn per acre.

	Pounds.
Yellow Dent.....	24,890
Sweet corn.....	36,960
B. and W. ensilage.....	47,040

Samples were very carefully taken in the following manner: As the cut ensilage dropped into the pit from the carrier a scoop-shovelful was caught about every five minutes and thrown to one side. The material accumulated in this way was thoroughly shoveled over and a large sample of a bushel or more taken, which was put into a large sausage cutter and chopped quite fine; this finely cut material was spread on the barn floor and a sample suitable for analysis secured, which was taken to the laboratory at once and dried.

	Yellow Dent (yield per acre, 24,890 pounds).		Large sweet (yield per acre, 36,960 pounds).		Burrill and Whitman ensilage (yield per acre, 47,040 pounds).	
	Per cent.	Total in one acre.	Per cent.	Total in one acre.	Per cent.	Total in one acre.
		<i>Lbs.</i>		<i>Lbs.</i>		<i>Lbs.</i>
Ash	2.22	597.4	2.04	753.7	1.59	748.0
Protein	2.49	619.7	2.12	783.4	1.81	851.5
Fat	0.49	122.0	0.45	166.3	0.28	134.2
Crude fiber	7.82	1,946.0	7.67	2,834.0	6.80	3,199.0
Nitrogen-free extract.....	15.98	3,977.4	10.37	3,832.0	7.22	3,396.0
Total dry matter.....	29.00	7,262.5	22.65	8,369.4	17.70	8,328.7

THE SILOS USED.

The largest bay in the main barn was converted into six experimental pits, each about 7 by 8 feet, inside measurement, and 14 feet deep. Studding were placed against the girts and on all sides of the bay, and building paper tacked to these. The sides were then boarded up with cheap matched fencing, care being taken to cut out all loose and open knots. Having boarded up in this way, studding were placed against the sides and paper, and boarded again. A partition was run lengthwise, of 2 by 8 inch studding, papered and boarded on each side. This partition divided the space into two long, narrow rooms. Each of these rooms was divided into three pits, of the dimensions before mentioned, viz, about 7 by 8 feet, inside measurement, by two partitions. These pits were amply large for experimental purposes, but most unfortunately small silos are far less successful in keeping ensilage than large ones.

A full week of preliminary feeding preceded each trial. When the feed of the cows was changed a week intervened before the trial was repeated. The animals were weighed three successive days at the beginning and close of each trial. In all the experiments the cows were given water warmed to 60° or 70° F., which was carefully weighed for each animal each day. The animals used were grade Jerseys, Holsteins, and Shorthorns. A considerable amount of the ensilage used was damaged, but all poor ensilage was avoided in the feeding experiment. The following tables show the results of the feeding experiments :

I.—*Results of feeding ensilage (large sweet corn).*

	Feed consumed.			Water drunk.	Product.	
	Ensilage.	Bran.	Corn meal.		Milk.	Butter.
	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs. Oz.</i>	<i>Lbs. Oz.</i>
First period (November 23 to December 13), Mattie and Purcell, 21 days ..	2,650	252	84	1,171	943 5	36 0
Second period (December 21 to January 10), Rose and Jessie, 21 days	2,310	252	84	1,205	745 9	26 3
Total	4,960	504	168	2,376	1,688 14	62 3

II.—*Results of feeding fodder corn (large sweet corn).*

	Feed consumed.			Water drunk.	Product.	
	Fodder corn.	Bran.	Corn meal.		Milk.	Butter.
	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs. Oz.</i>	<i>Lbs. Oz.</i>
First period (November 23 to December 13), Rose and Jessie, 21 days.....	639	252	84	2,621	735 13	30 8
Second period (December 21 to January 10), Mattie and Purcell, 21 days.....	588	252	84	2,614	751 15	28 3
Total	1,227	504	168	5,235	1,487 12	58 11

I.—Results of feeding ensilage (B. and W.).

	Feed consumed.			Product.	
	Ensilage.	Bran.	Corn meal.	Milk.	Butter.
	Lbs.	Lbs.	Lbs.	Lbs. Oz.	Lbs. Oz.
First period (January 23 to February 5), Yellow and Bessie, 14 days.....	1,780	168	56	596 5	21 12
Second period (February 13 to February 26), Bunn and Sylvia, 14 days	1,820	168	56	503 15	22 14
Total.....	3,600	336	112	1,100 4	44 10

II.—Results of feeding fodder corn (B. and W.).

	Feed consumed.			Product.	
	Fodder corn.	Bran.	Corn meal.	Milk.	Butter.
	Lbs.	Lbs.	Lbs.	Lbs. Oz.	Lbs. Oz.
First period (January 23 to February 5), Bunn and Sylvia, 14 days	458	168	56	591 9	23 10
Second period (February 13 to February 26), Yellow and Bessie, 14 days.....	371	168	56	521 7	20 15
Total.....	829	336	112	1,113 0	44 9

I—Results of feeding long ensilage (B. and W.).

	Feed given.				Product.	
	Ensilage fed.	Waste.	Bran.	Corn meal.	Milk.	Butter.
	Pounds.	Pounds.	Pounds.	Pounds.	Lbs. Oz.	Lbs. Oz.
First period (March 10 to 18), Beauty and Daisy, 9 days.....	1,074	9½	108	36	374 7	16 2
Second period (March 26 to April 3), Bessie and Bunn, 9 days	1,224	9	108	36	320 1	14 2
Total	2,298	18½	216	72	694 8	30 4

II—Results of feeding long fodder (B. and W.).

	Feed given.				Product.	
	Long fodder fed.	Waste.	Bran.	Corn meal.	Milk.	Butter.
	Pounds.	Pounds.	Pounds.	Pounds.	Lbs. Oz.	Lbs. Oz.
First period (March 10 to 18), Bessie and Bunn, 9 days.....	472	128	108	36	384 1	14 5
Second period (March 26 to April 3), Beauty and Daisy, 9 days	415	107	108	36	330 15	13 10
Total	887	235	216	72	715	27 15

In comparing the results of the first trial we can omit the odd ounces of milk produced, and bearing in mind that in each case 672 pounds of bran and corn meal were fed to supplement the coarser feed, we have :

4,960 pounds ensilage produced 1,688 pounds milk which made 62 pounds 3 ounces butter.

1,227 pounds fodder produced 1,487 pounds milk which made 58 pounds 11 ounces butter.

Excess in favor of ensilage, 201 pounds milk, 3 pounds 8 ounces butter.

In the second trial, when feeding 448 pounds of bran and corn meal, we have :

3,600 pounds ensilage produced 1,100 pounds milk which made 44 pounds 10 ounces butter.

829 pounds fodder produced 1,113 pounds milk which made 44 pounds 9 ounces butter.

Excess in favor of fodder, 13 pounds milk ; in favor of ensilage, 1 ounce butter.

In the third trial, when feeding long ensilage against long fodder, with 288 pounds of grain in each case, we have :

2,298 pounds ensilage produced 694 pounds milk which made 30 pounds 4 ounces butter.

887 pounds fodder produced 715 pounds milk which made 27 pounds 15 ounces butter.

Excess in favor of fodder, 21 pounds milk ; in favor of ensilage, 2 pounds 5 ounces butter.

In the first trial Mattie and Purcell shrank from 36 pounds of butter when fed ensilage to 28 pounds 3 ounces for the same length of time on dry fodder, while Rose and Jessie, giving 26 pounds 3 ounces of butter on dry fodder rose to 30 pounds 8 ounces when changed to ensilage. In the second trial the shrinkage in changing from one feed to another was about the same with both kinds of feed. With the third trial Beauty and Daisy shrunk from 16 pounds 1 ounce to 13 pounds 10 ounces changing from ensilage to fodder, while Bessie and Bunn, changing from fodder to ensilage, raised the product from 14 pounds 2 ounces to 14 pounds 5 ounces.

The following tables show the relative amount of dried fodder consumed in several trials :

First trial :

Ensilage fed, 4,960 pounds $\times$.2206 = 1,094.17 pounds, dry matter.

Dry fodder fed, 1,227 pounds $\times$.7805 = 957.67 pounds, dry matter.

Excess of dry matter fed in ensilage 136.50 pounds.

Second trial :

Ensilage fed, 3,600 pounds $\times$.1702 = 612.72 pounds, dry matter.

Dry fodder fed, 829 pounds $\times$.7275 = 603.97 pounds, dry matter.

Excess of dry matter fed in ensilage 8.75 pounds.

Third trial :

Long ensilage fed, 2,298 pounds $\times$.1688 = 387.90 pounds, dry matter.

Long dry fodder fed 887 pounds $\times$.7375 = 654.16 pounds, dry matter.

Excess of dry matter fed in fodder 266.26 pounds.

To make the comparison between ensilage and dry fodder as marked as possible we can calculate the amount of dry matter required to produce a pound of butter. Ignoring the grain fed (which was the same to both lots of cows), we have the following :

First trial :

17.5 pounds dry matter in ensilage produced 1 pound of butter.

16.3 pounds dry matter in dry fodder produced 1 pound of butter.

Second trial :

13.5 pounds dry matter in ensilage produced 1 pound of butter.

13.3 pounds dry matter in dry fodder produced 1 pound of butter.

Third trial :

12.8 pounds dry matter in long ensilage produced..... 1 pound of butter.

23.4 pounds dry matter in long dry fodder produced..... 1 pound of butter.

In this trial it will be remembered the cows failed to eat the coarse stalks.

Last year we found in a similar trial (see Fourth Report, 1887, p. 27):

15.69 pounds of dry matter in ensilage produced 1 pound of butter.

16.11 pounds of dry matter in corn fodder produced..... 1 pound of butter.

Losses in making ensilage and curing fodder.

	Loss in dry matter.
Sweet corn ensilage, silo No. 2.....	22.04 per cent.
Dried sweet-corn fodder.....	36.61 per cent.
Yellow-dent corn ensilage, silo No. 1.....	31.81 per cent.
Dried yellow-dent fodder corn.....	18.55 per cent.
B. and W. and flint mixed, silo No. 5	24.31 per cent.

From tests made to determine the relative storage room required for ensilage and dried fodder, it was concluded that there would be 4.25 pounds of dried matter in a cubic foot of hay, against over 7.26 to 7.95 in a cubic foot of ensilage. In large silos the ratio in favor of ensilage would be still greater. The following are the conclusions drawn from the experiment:

First. That dairy cows readily consume a sufficient quantity of corn ensilage to maintain a flow of milk and yield of butter fully equal to and rather more than that produced by feeding dry fodder corn.

Second. That the dry matter of ensilage has not shown a higher feeding value than the dry matter of carefully cured fodder corn.

Third. That we lost as much dry matter in fodder, that had been allowed to stand only one month in the field and was then shocked in the barn loft, as we did in that put into the silo.

Fourth. That while we know of no way to improve on the method employed for drying and storing fodder as practiced last season, it is probable that we can materially lessen the losses occurring in the silo in the future by improved practice.

Fifth. That about twice as much food can be stored in a given space in the shape of ensilage as in the form of hay.

Sixth. That long ensilage will go nearly twice as far in feeding cows as long fodder when large varieties of corn are used.

ENSILAGE VERSUS FODDER CORN FOR MILK PRODUCTION, F. W. A. WOLL, M. S. (pp. 28-63).

The experiment was divided into three periods, each period lasting three weeks. Two good milch cows which had been in milk for a couple of months were selected for the experiment. A week's preliminary feeding preceded the experiment proper.

During the first and third periods of the experiment cut yellow-dent fodder corn and a certain amount of bran and corn meal were fed, and during the second period sweet-corn ensilage was fed, with the same amount of grain feed as in the fodder-corn periods.

In order to ascertain the influence of the feed on the yield and the composition of the milk this was weighed daily during the experiment and subjected to chemical analysis.

Further, in order to determine the digestibility of the rations given, the excrement from each cow was collected and weighed during the last week of each period, and chemical analyses were afterwards made of the samples taken.

Animals used in the experiment.

Name of cow.	Breed.	Age.	Time of last calving.	Initial weight.	Notes.
		<i>Years.</i>		<i>Pounds.</i>	
Topsy	High-grade Holstein..	6	Sept. 8, 1887	1035	Served January 4, 1888.
Palmer	Grade Shorthorn	8	Sept. 28, 1887	840	Not served.

The fodder corn used in the first and the third period of the experiment was the Pride of the North, grown at the University farm during 1887; cut August 13-22, and allowed to stand out doors in shock until September 10-13, at which time it was stored away in the barn. Before feeding it was run through a feed-cutter and cut into half-inch pieces.

The ensilage fed during the second period was from a large variety of sweet corn, taken from experimental silo No. 2, season of 1887. It was of superior quality, and what has been termed "sweet" ensilage, of light brownish-green color, and of an agreeable aromatic odor.

The bran used in the experiment was from a car-load purchased in the fall of 1887 from the Minneapolis roller mills.

The corn meal was from a car-load of yellow-dent corn grown in the season of 1887 in Iowa. It was ground at the University farm.

The following table gives the chemical composition of the above-mentioned feeding stuffs:

	Fodder corn.	Corn ensilage.	Bran.	Corn meal.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Moisture	18.66	77.94	12.50	12.92
Dry matter	81.34	22.06	87.50	87.08
	100.00	100.00	100.00	100.00
100 parts of dry matter contained:				
Ash	5.19	7.74	6.89	1.38
Ether extract	1.79	3.58	4.87	4.32
Crude fiber	26.96	26.84	11.71	3.07
Crude protein	9.65	8.71	19.45	10.59
N.-free extract	56.41	53.53	57.08	80.64
	100.00	100.00	100.00	100.00
Albuminoids	7.16	4.51	12.93	8.73
Amides	2.49	4.20	6.52	1.86
Amide N	25.80	48.42	33.50	17.60

The ensilage contained 1.10 per cent of non-volatile acids (mainly lactic acid) and 0.21 per cent of volatile acids (mainly acetic acid).

METHOD OF CONDUCTING THE EXPERIMENT.

The cows were fed twice a day before milking, the grain feed being fed first and afterwards the coarse feed. In addition to their feed they got 10 grams of salt daily (equal to about one-third ounce). The fodder corn was cut in quantities large enough to last for about a week and sampled at the time of the cutting. In the samples for each week water and protein were determined. The coarse fodders were weighed out in linen bags each forenoon for night's and following morning's feed. The grain feed was weighed out in the same manner in wooden pails; it was sampled by taking a handful of each grain feed whenever a weighing was made, and setting it aside in a closed fruit jar till the end of each week; in these samples water was determined.

The cows were milked at 5 a. m. and 5 p. m. by the same farm hand and in the same order. About half a pint of the well-stirred evening's milk from each cow was put in an air-tight fruit-jar and kept over night in a cool place. In the morning a similar quantity was added from the morning's milk from each cow, and these mixed samples of milk, one from each cow, were then subjected to chemical analysis for total solids, fat, casein, and ash. The latter was determined only during the last week of each period, however, thus giving sufficient data during these weeks for calculating also the percentage of milk sugar in the milk. The specific gravity was determined in each sample of milk analyzed.

The milk from both cows, after being weighed and sampled, was poured into a Cooley can, and the cream kept and churned separately from that of the rest of the herd. Churnings were made twice a week.

The cows were watered once a day, at about 10 a. m., directly after having been weighed. A tank filled with water at 50° F. was placed on a Fairbanks platform-scale, and the weight of the tank was taken before and after the cows had drunk. After the cows were watered they were let out in the barn-yard for exercise when the weather was not too severe. Here they could get nothing to eat or drink. They were out from half an hour to three or four hours, according to the weather; on nice, mild days longer, on rainy, stormy days only for a short time. In the last week of each period they were not let out at all, however, on account of the collection of dung and urine. During these weeks the cows were kept in stanchions all the time. No special provision was made for them in regard to bedding or floor. Two watchmen were kept with the cows, one during the day and the other during the night, for the purpose of catching the dung and urine. These were collected separately with suitable arrangements, and were weighed and sampled after each twenty-four hours. In the urine the percentage of nitrogen and the specific gravity were determined each day and in the dung the water content. The subsamples of dung from each cow were mixed, and average samples representing the solid excrements for each week were taken for chemical analysis. The excrements were weighed on a Troemner solution balance, sensitive to one gram (equals .002 pound).

The temperature of the stable was taken three times a day, at 7 a. m., 1 p. m., and 8 p. m., and the average of these three readings was taken as the temperature of the day.

The cows were fed the following rations per day in the different periods:

TOPSY.	PALMER.
Period I:	Period I:
18 pounds fodder corn.	16 pounds fodder corn.
10½ pounds bran.	10 pounds bran.
2 pounds corn meal.	2 pounds corn meal.
Period II:	Period II:
48 pounds ensilage.	42 pounds ensilage.
Same grain feed as in Period I.	Same grain feed as in Period I.
Period III:	Period III:
Same ration as in period I.	Same ration as in Period I.

Topsy ate her feed clean during the whole experiment. In the first period, second and third week, and during the third period Palmer left more or less uneaten corn fodder each day.

The following table shows the average temperature of the stable during each period of the experiment:

Average temperature of each period.

Periods.	Last two weeks.	Whole period.
	°F.	°F.
Period I.....	45.4	46.4
Period II.....	42.8	43.7
Period III.....	37.5	38.4

Below will be found the weekly averages for the live weight of the cows and the water drunk per day :

Periods.	Topsy.		Palmer.	
	Live weight.	Water drunk.	Live weight.	Water drunk.
	<i>Pounds.</i>	<i>Pounds</i>	<i>Pounds.</i>	<i>Pounds.</i>
Period I:				
First week.....	963	60	849	75
Second week.....	961	88	854	71
Third week.....	965	90	850	81
Period II:				
First week.....	997	51	867	49
Second week.....	989	48	862	49
Third week.....	973	41	846	42
Period III:				
First week.....	941	71	819	79
Second week.....	966	86	826	71
Third week.....	960	71	820	72

Average dry matter eaten per day.

Periods.	Fodder corn.	Ensilage.	Bran.	Corn meal.	Total dry matter.	Total di- gestible matter.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
TOPSY.						
Period I:						
First week.....	*14.65		9.44	1.78	25.87	15.23
Second week.....	14.65		9.30	1.75	25.70	15.12
Third week.....	14.64		9.18	1.80	25.62	15.10
Period II:						
First week.....	1.03	11.04	9.21	1.73	23.01	14.84
Second week.....		11.07	9.16	1.77	22.00	14.18
Third week.....		11.07	9.15	1.72	21.94	14.15
Period III:						
First week.....	14.95		9.21	1.75	25.91	15.09
Second week.....	14.82		9.10	1.73	25.65	14.94
Third week.....	14.15		9.16	1.76	25.07	14.59
PALMER.						
Period I:						
First week.....	*13.02		9.00	1.78	23.80	14.32
Second week.....	12.86		8.85	1.75	23.46	14.11
Third week.....	12.65		8.74	1.80	23.19	13.96
Period II:						
First week.....	.87	9.66	8.77	1.73	21.03	13.13
Second week.....		9.69	8.73	1.77	20.19	12.61
Third week.....		9.69	8.71	1.72	20.12	12.64
Period III:						
First week.....	12.35		8.77	1.75	22.87	13.14
Second week.....	11.64		8.66	1.73	22.03	12.66
Third week.....	10.58		8.71	1.76	21.05	12.21

* Assuming same water content as in Period I, second week.

In addition to these rations 10 grams ($=\frac{1}{3}$ oz.) of salt was given each cow in their night feed.

The cows gave during the first week of the experiment on an average 19.75 pounds (Topsy) and 21.97 pounds (Palmer) per day; during the last week they gave 18.06

and 18.86 pounds per day, respectively, or a decrease of .003 pounds per day for Topsy, and .0056 pounds per day for Palmer. Supposing now the cows had been on the same feed during the whole experiment, the milk yield would have fallen off gradually the quantities mentioned, and we would have had figures as in the table below under the two columns headed "*calculated*."

The two columns headed "*difference*" give how much more (+) or less (—) milk was actually produced than the quantities calculated in the described manner.

Average yield of milk per day.

Periods.	Topsy.			Palmer.		
	Found.	Calculated.	Difference.	Found.	Calculated.	Difference.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Period I:						
First week	19.75	19.75	.....	21.97	21.97	.....
Second week	19.69	19.54	+1.15	21.15	21.58	— .43
Third week	21.59	19.33	+2.27	21.54	21.19	+ .35
Period II:						
First week	21.29	19.12	+2.17	21.72	20.80	+ .92
Second week	19.17	18.91	+ .26	20.26	20.41	— .15
Third week	17.73	18.70	— .97	19.38	20.02	— .69
Period III:						
First week	16.56	18.48	—1.92	18.43	19.63	—1.20
Second week	18.01	18.27	— .26	18.58	19.25	— .67
Third week	18.06	18.06	.....	18.86	18.86	.....

Average milk yield, last two weeks.

Periods.	Topsy.			Palmer.		
	Found.	Calculated.	Difference.	Found.	Calculated.	Difference.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Period I	20.64	.....	.....	21.35	.....	.....
Period II	18.45	19.34	— .89	19.80	20.04	— .24
Period III	18.04	.....	.....	18.72	.....	.....

Average composition of the milk.

Periods.	Topsy.						Palmer.					
	Sp. Gr.	Solids.	Fat.	Casein.	Sugar.	Ash.	Sp. Gr.	Solids.	Fat.	Casein.	Sugar.	Ash.
		<i>Per ct.</i>	<i>P. ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>P. ct.</i>		<i>Per ct.</i>	<i>P. ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>P. ct.</i>
Period I:												
First week	1.0331	13.34	4.29	3.18	.....	.....	1.0319	13.88	4.79	2.98*	.....	.....
Second week	.0323	13.07	3.70	3.23	.....	.....	.0330	14.19	4.68	3.22	.....	.....
Third week	.0317	13.40	3.94	3.09	5.58	.78	.0326	14.46	4.76	3.18	5.73	.79
Period II:												
First week	.0313	13.34	4.12	3.08	.....	.....	.0326	14.31	4.82	3.13	.....	.....
Second week	.0330	13.39	4.33	3.12	.....	.....	.0341	14.00	4.78	3.16	.....	.....
Third week	.0319	13.43	4.34	3.06	5.28	.75	.0331	14.39	4.91	3.17	5.52	.79
Period III:												
First week	.0320	13.92	4.59	3.15	.....	.....	.0337	14.94	4.89	3.36	.....	.....
Second week	.0316	13.66	4.38	3.25	.....	.....	.0326	14.88	5.24	3.39	.....	.....
Third week	.0321	13.82	4.38	3.01*	5.64	.79	.0330	14.85	5.18	3.30	5.59	.78

* Probably too low.

If we only consider the last two weeks of each period the specific influence of the ensilage feeding will become more apparent; as we did before we put the mean of the two fodder-corn periods against the ensilage period.

Composition of milk, last two weeks.

TOPSY.

Periods.	Specific gravity.			Total solids.			Milkfat.			Casein.		
	Found.	Calculated.	Difference.	Found.	Calculated.	Difference.	Found.	Calculated.	Difference.	Found.	Calculated.	Difference.
I	1.0320			<i>P. ct.</i> 13.23	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i> 3.82	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i> 3.16	<i>P. ct.</i>	<i>P. ct.</i>
II	1.0324	1.0320	+.0004	13.41	13.49	— .08	4.34	4.10	+.24	3.09	3.14	— .05
III	1.0319			13.75			4.38			3.12		

PALMER.

I	1.0328			14.34			4.72			3.20		
II	1.0336	1.0328	+.0008	14.19	14.61	— .42	4.84	4.97	— .13	3.16	3.28	— .12
III	1.0328			14.87			5.21			3.35		

Total daily production in pounds.—Weekly averages.

Periods.	Topsy.			Palmer.		
	Milk solids.	Milk fat.	Casein.	Milk solids.	Milk fat.	Casein.
Period I:						
First week	2.59	.849	.628	3.05	1.046	.655
Second week	2.58	.728	.608	3.02	.997	.684
Third week	2.90	.852	.667	3.15	1.022	.681
Period II:						
First week	2.85	.884	.654	3.11	1.047	.675
Second week	2.57	.831	.598	2.84	.964	.638
Third week	2.38	.709	.540	2.78	.950	.609
Period III:						
First week	2.30	.759	.522	2.76	.905	.625
Second week	2.46	.788	.584	2.77	.978	.629
Third week	2.52	.794	.542	2.80	.975	.622

Total daily production in pounds, last two weeks.

TOPSY.

Periods.	Milk solids.			Milk fat.			Casein.		
	Found.	Calculated.	Difference.	Found.	Calculated.	Difference.	Found.	Calculated.	Difference.
Period I	2.74			.790			.638		
Period II	2.48	2.62	— .14	.770	.791	— .021	.569	.601	— .032
Period III	2.49			.791			.563		

PALMER.

Period I	3.09			1.010			.683		
Period II	2.81	2.94	— .13	.957	.994	— .037	.624	.655	— .031
Period III	2.79			.977			.626		

One pound of digestible matter produced—

[Daily averages during each period (only last two weeks considered).]

Periods.	Topsy.				Palmer.			
	Milk.	Milk solids.	Milk fat.	Casein.	Milk.	Milk solids.	Milk fat.	Casein.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Period I.....	1.366	.182	.052	.042	1.521	.220	.072	.049
Period II.....	1.303	.175	.055	.040	1.620	.223	.076	.050
Period III.....	1.222	.169	.054	.038	1.507	.224	.079	.051

Taking the mean of the figures for the first and third periods (the fodder-corn periods) and comparing the quantities thus found with the figures for the ensilage period (second period), we find how much more or less was produced by one pound of digestible matter during the ensilage period than during the corn-fodder periods.

Greater (+) or smaller (−) production for every pound of digestible matter during the ensilage period than average of the two fodder-corn periods.

Name.	Milk.	Milk solids.	Milk fat.	Casein.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Topsy	+.005	−.001	+.002	.....
Palmer	+.101	+.001	.....	.....

The results given in the tables quoted are illustrated in the report by diagrams which greatly help to make them clear and forcible.

BUTTER PRODUCED.

The milk from both cows was set in a Cooley can and submerged in ice water, each milking by itself. The cream was drawn off after twelve hours. It was properly cured and afterwards churned, taking three and a half days' mess into each churning. As this part of the experiment was thought of no considerable importance at the beginning of the experiment, the milk was not set separately, nor was the butter produced subjected to chemical analysis. The butter was salted and well worked before being weighed.

The total amount of butter produced during the experiment was :

	<i>Pounds.</i>
Period I (fodder corn).....	40.38
Period II (ensilage)	38.63
Period III (fodder corn).....	33.62

The mean between the first and third periods will be 37 pounds or 1.63 pounds less than was actually produced during the ensilage period.

If we take into account the last two weeks of each period and calculate the number of pounds of milk which was required to make one pound of butter, we get the following :

One pound of butter produced from—

Period I.....	21.66 lbs. of milk.
Period II.....	20.43 lbs. of milk.
Period III.....	23.42 lbs. of milk.

The average of first and third periods is 22.54 pounds, or 2.11 pounds more than the number of pounds which was required to make 1 pound of butter during the ensilage period; on account of the ensilage feed 1 pound of butter was consequently produced from 2.11 pounds of milk less than would have been the case if fodder corn had been fed during the period.

By the churnability of the fat we understand the percentage of milk fat which is churned out and re-appears in the butter. We shall see in the following table the churnability of the fat in the different periods of this experiment. For this purpose we assume the butter to contain, on an average, 85 per cent of fat, since it was not analyzed. As we want to find out the influence of the rations in each period we have to throw out the first week of each period, the milk given during this week being doubtless influenced by the feed in the preceding period. If we then only consider the last two weeks of each period we have—

Churnability of milk fat, from milk of both cows.

Periods.	Butter.	Butter fat (85 per ct.).	Milk fat.	Churned out.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Per cent.</i>
Period I	6.50 7.00 6.75 6.88 7.00	23.06	25.19	91.54
Period II	6.50 7.25 5.75 5.75			
Period III	5.56 5.62 5.56			

If we take only the last week of each period into consideration, the following results were obtained:

Periods.	Butter.	Butter fat.	Milk fat.	Churned out.	Average.	Differ- ence.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Period I	13.63	11.59	13.12	88.35	.....	.....
Period II	13.00	11.05	11.61	95.15	82.45	+12.60
Period III	11.18	9.50	12.38	76.74	.....	.....

The difference in the churning quality of the milk is here 12.60 per cent in favor of the milk from the ensilage period. This result shows a greater improvement of the milk as regards this point than is shown by consideration of the data from the last two weeks of each period. This may be only accidental or it may tend to show that the feed influences the churnability of the milk fat even after the lapse of more than a week. We know too little yet about this question to say which is more likely to be the case.

As stated in the introduction to this discussion, the digestibility of the different rations was determined during the third week of each period. We shall here confine ourselves to give directly the digestibility co-efficients found for the rations. Below will be found the chemical composition of the six samples of dung which were collected during the experiment.

Composition of samples of dung.

Name of cow.	Water.	Dry matter.	100 pounds dry matter contained—						
			Ash.	Ether extract.	Crude fiber.	Crude protein.	N.-free extract.	Albuminoids.	Amides.
Topsy:	<i>Per ct.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First period...	83.08	16.92	12.16	3.07	24.43	11.73	48.61	9.75	1.98
Second period	83.46	16.54	15.89	2.49	23.94	11.76	45.92	9.85	1.91
Third period ..	82.80	17.20	11.81	2.33	23.78	11.83	50.25	9.90	1.93
Palmer:									
First period...	83.35	16.65	13.04	2.34	22.94	11.98	49.70	9.75	2.23
Second period.	83.93	16.07	16.13	3.11	22.60	11.47	46.69	10.09	1.38
Third period ..	82.52	17.48	12.66	2.50	22.41	11.76	50.67	9.66	2.10

Digestibility of rations fed.

Periods.	Dry matter.	Organic matter.	Ether extract.	Crude fiber.	Crude protein.	N.-free extract.	Albuminoids.	Amides.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Period I:								
Topsy	58.9	61.8	59.5	49.3	81.7	65.7	57.1	78.8
Palmer	60.1	63.3	69.9	52.4	82.0	66.3	59.1	77.2
Period III:								
Topsy	58.2	60.4	69.9	49.6	79.1	64.0	54.9	79.4
Palmer	57.4	60.6	67.6	45.9	79.7	63.9	57.7	77.8
Average digestibility of fodder-corn ration.....	59.0	62.0	67.0	49.0	81.0	65.0	57.0	78.0
Period II:								
Topsy	64.4	67.8	76.8	67.2	83.9	67.3	57.9	86.2
Palmer	62.4	66.2	71.4	53.7	83.8	69.4	55.6	90.0
Average digestibility of ensilage ration ..	63.0	67.0	74.0	61.0	84.0	68.0	57.0	88.0

*The percentages of digestible crude protein have been corrected for the amount of crude protein redigested in the samples of dung by a pepsin-pancreas solution (Stutzer's method). No attempt has been made to carry the correction over on the albuminoids or the amides. As will be seen from the above table, the samples of dung all contained considerable quantities of amides.

The feeding stuffs used in this experiment and the rations fed were subjected to artificial digestion according to the method devised by the German scientist, Dr. A. Stutzer. The fodders are dried and ground finely and treated with a dilute pepsin solution for forty-eight hours at about 102° F.; afterwards the residue is treated with a pancreas (sweet-bread) solution for twenty-four hours. This method gives nothing but the nitrogen digested out by the solutions. In all cases either duplicate or triplicate determinations were made.

Percentage of digestible protein found by—

	Artificial digestion.	Natural digestion.
	<i>Per cent.</i>	<i>Per cent.</i>
Yellow dent fodder-corn.....	66.0	.....
Sweet-corn ensilage	62.8	.....
Bran	85.2	.....
Corn meal.....	84.2	.....
Fodder-corn ration	80.1	80.7
Ensilage ration.....	81.4	83.9

The results obtained in this experiment may be summarized as follows:

(1) The live weight of the cows increased directly after the first fodder-corn period, and decreased again directly after the ensilage period, apparently on account of increased retention of food or water in the body of the animals.

(2) The milk produced during the ensilage period was poorer in composition as regards total solids and casein, while the percentage of fat in the milk was smaller in one case and larger in the other than was that produced in the fodder-corn periods.

(3) The quantity of milk given decreased during the ensilage period.

(4) The quantities produced of milk solids, milk fat, and casein decreased on the ensilage feed.

(5) Considering the quantities of milk solids, milk fat, and casein produced by one pound of digestible matter in the ensilage ration and in the fodder-corn ration, we find practically no difference in the nutritive effect of the two rations, only that the ensilage ration produced a somewhat thinner milk.

(6) Twelve and sixty one-hundredths per cent more of the fat was churned out from the mixed milk of both cows when the cows were fed on ensilage than when they received fodder corn, the last week of each period being considered.

(7) The digestibility of the ensilage ration was somewhat higher than that of the fodder-corn rations; the crude fiber and the crude protein of the sweet-corn ensilage appear to be more digestible than the crude fiber and protein of the yellow dent fodder-corn.

ENSILAGE FOR STEER-FEEDING, W. A. HENRY, B. AGR. (pp. 63-66).

On November 22, 1887, we purchased eight large steers, six of which were three-year-olds and two were two-year-olds. They all had some Shorthorn blood in them and were above the average cattle in this section, although not nearly so good as such cattle should be. We dehorned them November 23, and fed corn fodder without grain to November 25. On the 26th we began feeding ensilage. They were divided into two lots of four each. One lot received ensilage only, while the other lot received ensilage, shelled corn, and bran. Each lot of four ran loose in a closed shed or room 25 by 26 feet, with a large feed-box across one side. Although they were large cattle, owing to the fact that their horns were removed they had ample room; indeed, we could have put twice as many in the same inclosure without any apparent discomfort. Water was kept constantly before them in a trough. They were weighed on three successive days, at the beginning and close of the trial, and the average of these weights taken for the normal weight. The experiment began on the 2d of December, and closed on the 6th of January, running thirty-six days.

The design of the experiment with the first lot was to see if steers could be maintained or would make any growth upon corn ensilage which contained little or no grain, and with the second lot to ascertain if ensilage was a favorable feed to accompany corn and bran for fattening cattle. The ensilage used in this experiment was from silo No. 5, which was filled with wilted mixed Burrill and Whitman and yellow flint fodder which contained very little grain—not enough to be considered, though some of the stalks had some semblance of ears on them. Such ensilage could be produced at the rate of about 40,000 pounds to the acre, or if well wilted, as was this, an acre would furnish not less than 30,000 pounds of material as it went into the silo. The following figures explain the details and results of the experiment:

Weight of steers.

Dates.	Getting ensilage.				Getting ensilage and grain.			
	1.	2.	3.	4.	1.	2.	3.	4.
December 1.....	1,292	1,105	1,250	1,315	1,281	1,210	1,125	1,084
December 2.....	1,303	1,082	1,217	1,298	1,253	1,191	1,125	1,093
December 3.....	1,291	1,095	1,289	1,286	1,249	1,202	1,113	1,102
January 5.....	1,400	1,162	1,290	1,356	1,380	1,340	1,260	1,265
January 6.....	1,385	1,150	1,270	1,335	1,360	1,342	1,250	1,242
January 7.....	1,371	1,160	1,280	1,330	1,365	1,355	1,225	1,249

Getting ensilage.

Average weight of lot at beginning...lbs..	4,941
Average weight of lot at close.....do...	5,163
Gain in thirty-six days.....do....	222

Getting ensilage and grain.

Average weight of lot at beginning...lbs..	4,676
Average weight of lot at close.....do...	5,211
Gain in thirty-six days.....do....	535

Feed consumed by steers in thirty-six days.

	Pounds.
Lot getting ensilage only.....ensilage..	7,898
Lot getting ensilage and grain.....do.....	3,502
Together with .....shelled corn..	2,108
And.....bran..	970

Lot fed ensilage only gained 1.5 pounds each daily; lot fed ensilage and grain gained 3.7 pounds each daily; to make 100 pounds of gain required with ensilage only 3,558 pounds.

To make 100 pounds gain with ensilage and grain required 654 pounds ensilage, fed with 394 pounds corn and 181 pounds bran.

Four hogs were placed with the steers getting grain in order to consume the waste in the droppings; it was found they required only 92 pounds additional corn to make 100 pounds of gain.

It may be said, therefore, that in this trial 654 pounds of ensilage and 669 pounds of corn and bran gave a gain of 100 pounds with the steers and 100 pounds with hogs running with the steers.

Assuming that such ensilage as we fed was worth \$4 per ton, and the mixture of corn bran \$15 per ton, we can calculate what it costs to produce 100 pounds of gain in these experiments.

To make 100 pounds of gain from ensilage only, we have 3,558 pounds of ensilage, at \$4 per ton, \$7.11.

To produce 100 pounds of gain with ensilage and grain, we have:

575 pounds of grain, at \$15 per ton.....	\$4.31
654 pounds ensilage, at \$4 per ton.....	1.30
Total cost of 100 pounds gain.....	5.61

To produce 100 pounds of gain with steers and 100 pounds gain with hogs, or 200 pounds gain in all, required:

669 pounds grain, at \$15 per ton.....	\$5.02
654 pounds of ensilage, at \$4 per ton.....	1.30
Cost of 100 pounds beef and 100 pounds pork.....	6.32

If we allow that an acre of land will produce 25,000 pounds of wilted ensilage, such as was used in this trial, and such an amount is a reasonable estimate, since 3,558 pounds made 100 pounds of gain with the first lot of steers, an acre of ensilage will give over 700 pounds of gain with steers such as ours were. Here are results satisfactory to the most exacting. Ensilage has proved a valuable feed with us for steers, and we can, with considerable confidence, recommend it.

In the above estimate \$4 per ton for ensilage is a very large sum to allow, since allowing 12½ tons of wilted ensilage per acre would give a gross revenue of \$50 per acre.

COMPARISON OF SHOCKING AND SILOING FODDER CORN, W. A. HENRY, B. AGR., AND F. W. A. WOLL, M. S. (pp. 67-74).

The plan of the experiments was as follows: Six silos, each one of a capacity of about 12 tons (dimensions of the silos 8 by 7 and 14 feet deep), were built in a large bay in the barn at the University farm. These silos were filled during the months of August and September, 1887, with fodder corn of different varieties and in different states of curing. In case of three of the silos every other load of fodder was carried back to the field after having been weighed and was there shocked, while the other loads were run through a feed-cutter, cut into half-inch slices, and filled into the silo. Slow filling was practiced. Samples of the fodders were taken as filled into the silos, also when the silos were opened, and likewise when the dry corn-fodder was fed to cattle. The weights of the fodder put into the silos and of

the ensilage taken out, as well as of the fodder shocked and stored away, were carefully taken. The fodders shocked in the field remained there for a month; the sweet-corn was reshocked once in the field, as it had commenced to heat. September 10 to 13 it was stored in the barn protected from rain. The stalks were put standing erect, much as they were shocked in the field; great care was taken to secure thorough ventilation in order to prevent the fodder from spoiling. The silos were numbered 1 to 6. For the three silos Nos. 1, 2, and 5 we have complete data. Of these silos No. 2 and No. 5 gave ensilage second to none in quality. The ensilage in silo No. 1, on account of the cracking of a board in the wall, was not as good as might be wished for, especially in the lower parts of the silo. Making due allowance for this fact, however, we can still use the figures and results obtained, especially since they go together with those from the other silos.

Yellow dent corn of the common Wisconsin variety was cut and the same day put into silo No. 1; large sweet corn, fresh cut, was put into silo No. 2, and Burrill and Whitman Southern ensilage corn and yellow flint corn mixed, having been shocked in the field for about a week, was filled into silo No. 5. A great amount of labor was expended in following the change of the temperature in the silos.

The highest temperature observed in any place in silo No. 1 was 120° F., and in silo No. 5, 122° F.; in both cases the highest temperature was reached during the first week of the siloing period, after which time the temperature went down slowly but steadily. An exception to this was experienced in case of silo No. 1, where a second heating occurred, being caused by the admission of air through the wall of the silo. The temperature here, after having gradually gone down to 82° 4 F., suddenly rose to 98° 6 around the tube going down into the middle of the silo within 6 feet from the bottom.

The following tables show the results of the chemical analyses and of the weighings of dry fodder and ensilage:

Yellow dent corn—silo No. 1.

	Cured fodder.				Siloed fodder.			
	When cut.	When cured.	Difference.		When cut.	When siloed.	Difference.	
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Per ct.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Per ct.</i>
Weight of fodder	17,408.0	4,998.0	-12,410.0	.. .....	21,605.0	14,538.0	-7,067.0	.....
Dry matter	5,048.0	4,112.0	- 936.0	-18.55	6,266.0	4,273.0	-1,993.0	-31.81
Ash	386.2	234.7	- 151.5	- 3.00	479.4	376.9	- 102.5	- 1.64
Ether extract.....	84.8	78.2	- 6.6	- .13	105.3	104.1	- 1.2	- .02
Crude fiber	1,361.0	1,277.0	- 84.0	- 1.66	1,690.0	1,407.0	- 283.0	- 4.52
Crude protein	433.6	426.4	- 7.2	- .14	538.3	391.7	- 146.6	- 2.34
Nitrogen-free extract.	278.3	2,095.7	- 687.0	13.62	3,453.0	1,993.3	-1,459.7	-23.29

Large-sweet corn—silo No. 2.

	Cured fodder.				Siloed fodder.			
	When cut.	When cured.	Difference.		Fresh.	Siloed.	Difference.	
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Per ct.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Per ct.</i>
Weight of fodder	17,908.0	3,279.0	-14,629.0	.....	24,516.0	19,628.0	-4,888.0	.....
Dry matter	4,057.0	2,572.0	- 1,485.0	-36.61	5,554.0	4,330.0	-1,224.0	-22.04
Ash	365.4	212.7	- 152.7	- 3.76	500.9	396.3	- 104.6	- 1.88
Ether extract.....	80.6	83.3	+ 2.7	+ .07	110.5	155.0	+ 44.5	+ .80
Crude fiber	1,374.0	886.5	- 487.5	-12.01	1,881.0	1,151.0	- 730.0	-13.14
Protein	379.6	281.7	- 97.9	- 2.41	520.4	373.8	- 146.6	- 2.64
Nitrogen-free extract.	1,857.0	1,109.0	- 748.0	-18.44	2,541.0	2,254.0	- 287.0	- 5.17

Burrill and Whitman ensilage corn and yellow flint corn—silo No. 5.

	When fresh.	When siloed.	Difference.	
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Per cent.</i>
Dry matter.....	5,842.0	4,422.0	—1,420.0	—24.31
Ash	462.8	481.8	+ 19.0	+ .33
Ether extract.....	85.3	114.8	+ 29.5	+ .51
Crude fiber	1,997.0	1,435.0	— 562.0	— 9.62
Protein.....	511.8	389.2	— 122.6	— 2.10
Nitrogen-free extract.....	2,785.1	1,999.2	— 785.9	—13.46

The above results, and still more the results of the analyses of siloed and of dry corn indicate that the mineral matter in the siloed fodder is in some way subject to translocation, caused by pressure of the upper layers on the lower ones, or by movement of the juices of the green fodder or by diffusion. In this way there will be an accumulation of mineral matter at some places and a diminution at other places. The sampling of the ensilage so as to get a fair content of the ash in the sample will, if this is the case, be a matter of great difficulty, as we have as yet no experimental data in regard to the subject, and know consequently nothing of the direction in which the mineral matter is liable to move. It is, however, evident from the above that it is a faulty manner of proceeding to calculate the components of the siloed fodder from a single analysis, on basis of the supposition that the ash constituents remain unchanged. Where there is no leakage, the same quantity of mineral matter will be in the silo at the end of the siloing period as before; but a single analysis will not, as a rule, indicate the true quantity of the ash component in the silo. What has been said above only has reference to the mineral matter and does not affect the reliability of the sampling as regards the other constituents of the fodder in a similar degree, since the ash is the only component subject to such translocation and since it is present in but small quantities.

Returning to the question of the losses in preserving fodder corn either by the shocking system or through the siloing process we have as an average of two trials a loss of 27.58 per cent of dry matter in the fodder and 26.06 per cent in the latter. These trials are certainly too few to generalize from, but the former result coming so unexpectedly high can not but lead us to reflect a little on the practice which perhaps a majority of our farmers still follow in preserving their fodder corn for feeding purposes. If fodder corn loses more than one-fourth of its value as a food on being shocked in the field for a month and afterwards being kept under the most favorable condition, how great is the loss in case it is left in the field during the whole fall and winter, subject to the severity of the season with rain and snow storm? A great many farmers do not haul in their corn fodder till needed for feeding and do not consider that by this practice they are robbing themselves of a very appreciable quantity of food material for their cattle. The way to do, as suggested by the above trials and as shown by the experiences of successful dairymen, is to store away the corn fodder under roof protected from rains, as soon as it is cured, or to fill it into a silo at once after it is wilted. Which of the two methods we choose may be considered a question of economy; the silo for one thing has the advantage of requiring far less room to store the same number of tons of fodder than does the shocking system.

SILOED CORN VERSUS MATURED DRIED CORN, F. W. A. WOLL, M. S. (pp. 75–81).—Analyses of a number of varieties of corn, which were made to determine the nutritive value of siloed corn as compared with that of matured dried corn, gave the following average results :

1,000 kernels contained on an average—

[In grams.]

	Dry matter.	Ash.	Ether extract.	Crude fiber.	Crude pro- tein.	N.-free extract.
Matured dried corn (average of eight samples)	276.45	5.11	14.40	5.63	31.42	219.89
Siloed corn (average of nine samples)	209.16	3.36	12.78	5.24	21.07	166.58
Loss in siloing process	67.29	1.75	1.62	.39	10.35	53.31
In per cent	24.34	34.25	11.25	6.93	32.45	24.22
Calculated on dry matter in original corn:						
Per cent loss	24.34	.63	.59	.14	3.66	19.29

ANALYSES OF FODDER CORN AND CORN ENSILAGE, F. W. A. WOLL, M. S. (p. 82-85).—The results of the analyses of green fodder corn, corn ensilage, and clover ensilage made at the Station during the year are given in tabular form.

NOTES ON ENSILAGE, W. A. HENRY, B. AGR. (pp. 86, 87).—This article contains notes on dried ensilage and ensilage for sheep and hogs.

STEER-FEEDING EXPERIMENTS, W. A. HENRY, B. AGR. (pp. 87-92).—This article contains an account of an experiment to determine the relative values of whole corn and corn meal for steer feeding. First, when the steers were by themselves; second, when hogs followed the steers. A similar trial made in 1887 was reported in the Fourth Annual Report, pages 56-60. The results of the two experiments are summarized as follows:

In 1888.—To make 100 pounds live weight with steers required, when fed whole corn, 402 pounds hay and 802 pounds corn and bran; when fed corn meal, 453 pounds hay and 875 pounds corn meal and bran. Hogs following these steers required, when fed whole corn, 35 pounds corn additional, and when fed corn meal 420 pounds corn additional to make 100 pounds gain, live weight.

In 1887.—To make 100 pounds live weight with steers one year old required, when fed whole corn, 633 pounds hay and 551 pounds corn and bran; when fed corn meal, 589 pounds hay and 465 pounds corn meal and bran. Hogs following these steers required, when fed whole corn, 272 pounds corn additional, and when fed corn meal 479 pounds corn additional to make 100 pounds gain, live weight.

EXPERIMENTS IN PIG-FEEDING, W. A. HENRY, B. AGR. (pp. 92-107).—This article contains the details of the experiments in pig-feeding made at the Station during the year. The lines of the investigation are as follows: (1) Whole corn *versus* corn meal with heavy and light hogs. In this experiment the heavy hogs gave the best results with corn meal; but the light hogs with whole corn. (2) Corn meal and skim milk for pigs. (3) Wet *versus* dry feed for hogs. The feed consisted of equal parts of corn meal and shorts. The results were in every case in favor of wet feed. (4) Milk and corn meal for pig-feeding. The trial indicates that if rapid production of pork is desired a pound or pound and one-half of milk to one pound of corn meal is as much as can be profitably fed when milk is valued at 20 to 25 cents and meal at 75 cents per 100 pounds. (5) Effects of corn meal, shorts,

and skim-milk on the carcass and internal organs of the hog. (Illustrated.)

The following conclusions are drawn from this experiment :

(1) In regard to the amount of blood secured at killing-time from the different lots it would seem that the feeding of milk does not increase the percentage of blood over the feeding of corn meal. We get a smaller per cent of blood in lot C, of the second trial, fed milk, than with B in the same trial, fed on corn meal. In the first trial the hogs receiving the most milk gave the smallest percentage of blood. From feeding shorts we obtained the large amount of nearly $4\frac{1}{2}$ pounds of blood to 100 pounds of dressed weight. The reader will note by examining the cuts presented that the muscles of the hogs fed on shorts appear dark, indicating the deep red color of the lean meat, while that of the corn-fed animals appeared very light colored and bloodless. The milk-fed hogs gave an intermediate colored meat.

(2) Milk and shorts each increase the weight of the liver over that produced by feeding corn meal.

(3) Milk and shorts each increase the weight of the kidneys over corn meal.

(4) With a spleen we get contradictory figures, and must leave the question open at this time.

(5) Regarding the strength of the bones we have no doubtful figures to perplex us. Where the most milk was fed the bones were the strongest. Shorts made a strong bone, but not quite equal to that produced by milk.

(6) With reference to the varying proportions of fat and muscles to each other, the illustrations presented show the facts in the case better than any descriptions by us.

Whatever figures have been presented by the writer upon this topic are given with the idea that all he is doing is but a preliminary survey in a most important field of investigation, one which promises excellent returns, both from the scientific and economic stand-point. Indian corn is the great grain crop of America, and, while not used in any very large amount for human food, it is the common grain food for all kinds of live stock. Our feeding trials show, what the experience of our farmers has long taught, that for feeding purposes, compared with its cost price, corn is the cheapest grain we have.

SUMMARY OF EXPERIMENTS IN PIG-FEEDING AT THE STATION, W. A. HENRY, B. AGR. (pp. 108-111).—The following tables give the results of experiments in pig-feeding made at the Station for several years :

Summary of pig-feeding trials at this Station.

Kind of feed.	Number of animals fed.	Total weight at beginning of trial.	Number of days of trial.	Gain.	Amount eaten.	Time of year of trial.	Where reported.
		<i>Lbs.</i>		<i>Lbs.</i>	<i>Lbs.</i>		<i>Rep. pp.</i>
Whole corn	2	435	14	45	233	Mar.-Apr.	II 26
	3	652	28	92	756	Feb.-Mar.	III 36
	3	692	28	90	792	Feb.-Mar.	III 36
	2	105	25	42	169	July-Aug.	I 33
	2	172	25	61	253	Aug.-Sept.	I 33
Corn meal.....	2	123	18	33	168	Sept.	I 34
	3	188	42	104	558	July-Aug.	III 34
	3	616	21	77	432	Jan.	IV 70
	3	657	21	85	365	Feb.	IV 70
	3	270	136	291	1,690	June-Nov.	IV 86
Corn meal, cooked	2	146	98	202	942	Dec.-Mar.	V 00
	3	597	21	64	400	Jan.	IV 70
	3	715	21	78	406	Feb.	IV 70

Summary of pig-feeding trials at this Station—Continued.

Kind of feed.	Number of ani- mals fed.	Total weight at beginning of trial.	Number of days of trial.	Gain.	Amount eaten.	Time of year of trial.	Where reported.
		<i>Lbs.</i>		<i>Lbs.</i>	<i>Lbs.</i>		<i>Rep. pp.</i>
Barley meal.....	3	379	23	85	400	Oct.	IV 68
	3	450	23	50	430	Nov.	IV 68
	3	493	21	67	395	Dec.	IV 69
	3	586	21	81	380	Jan.	IV 69
	3	390	23	46	392	Oct.	IV 68
Barley meal, cooked.....	3	465	23	68	406	Nov.	IV 68
	3	497	21	76	397	Dec.	IV 69
	3	611	21	69	380	Jan.	IV 69
Shorts.....	3	176	42	95	501	July-Aug.	III 34
Sweet skim-milk	2	113	25	59	1,168	July-Aug.	I 33
	2	153	25	79	1,264	Aug.-Sept.	II 33
Two parts corn and one part shorts.....	3	550	28	102	673	Jan.-Feb.	III 35
	3	587	28	105	746	Jan.-Feb.	III 35
	3	447	21	110	540	Winter.	III 37
Two parts corn and one part shorts, cooked.	3	464	21	82	496	Winter.	III 36
One part corn and two parts shorts	3	437	21	94	439	Winter.	III 37
One part corn and two parts shorts, cooked.	3	467	21	82	429	Winter.	III 37
Corn meal and shorts, half and half	3	185	42	107	469	July-Aug.	III 34
	3	390	23	89	407	Oct.	IV 69
	3	507	23	64	443	Nov.	IV 69
Corn meal and shorts, half and half, cooked.	3	410	23	76	400	Oct.	IV 69
	3	493	23	64	428	Nov.	IV 69
Corn meal and shorts, half and half, fed dry.	3	343	34	127	570	Sept.-Oct.	V 95
	3	512	34	128	658	Oct.-Nov.	V 95
	3	331	34	63	472	Sept.-Oct.	V 95
	3	467	34	98	511	Oct.-Nov.	V 95
	3	346	34	165	622	Sept.-Oct.	V 95
Corn meal and shorts, half and half, fed wet.	3	504	34	172	739	Oct.-Nov.	V 95
	3	343	34	111	508	Sept.-Oct.	V 95
	3	448	34	109	532	Oct.-Nov.	V 95
One part corn meal and two parts shorts.	2	145	98	162	818	Dec.-Mar.	V 100

Summary of pig-feeding trials at this Station—Continued.

Kind of feed.	Number of ani- mals fed.	Total weight at beginning.	Number of days of trial.	Gain.	Amount eaten.		Time of year.	Where reported.
		<i>Lbs.</i>		<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>		<i>Rep. Pp.</i>
Corn meal and sweet skim-milk {	2	118	18	59	77	403	Sept.	I 34
	2	122	18	76	70	733	Sept.	I 34
	2	124	18	76	156	257	Sept.	I 34
	2	295	25	128	297	1,039	June.	I 36
	2	300	25	100	148	1,485	June.	I 36
Corn meal and shorts, equal parts, and sweet skim-milk.	3	(?)	96	420	1,445	2,890	July-Sept.	IV 24
Corn meal and shorts, equal parts, and buttermilk.	3	(?)	96	382	1,445	2,890	July-Sept.	IV 24
Corn meal and sweet skim-milk {	3	772	30	176	674	337	Apr.-May.	V 92
	3	958	30	154	536	268	June-July.	V 92
	2	350	30	104	432	216	Apr.-May.	V 92
	2	466	30	94	362	181	June-July.	V 92
	3	785	30	146	704	352	May-June.	V 93
Whole corn and skim-milk	3	953	30	104	497	248	June-July.	V 93
	2	330	30	93	306	153	May-June.	V 93
	2	446	30	77	308	154	June-July.	V 93
Corn meal and skim-milk.....	6	734	55	496	1,572	4,716	Feb.-Apr.	V 94
	2	142	98	239	638	1,962	Dec.-Mar.	V 100
Corn meal and buttermilk	3	116	135	553	1,183	4,140	July-Nov.	V 97
	3	108	135	424	1,229	1,117	July-Nov.	V 97
	3	108	135	372	1,263	421	July-Nov.	V 97

The reader is asked to bear in mind that these figures are only preliminary ones, and that future trials may somewhat modify them. The writer considers that the

amount of corn meal required to produce 100 pounds of gain with shorts in summer, as here stated, is too high, and that 500 pounds of meal for 100 pounds of gain in summer with animals of such weight is ample. Of course the figures must be given just as we find them.

While small changes may be made, as indicated, still the table will in general answer the important question often asked, how much feed for 100 pounds of pork.

Table showing the amount of feed required to make 100 pounds of gain with hogs.

Kind of feed.	Time of year.	No. of trials.	No. of animals.	Average weight at beginning of trial.	Food required for 100 pounds of gain.
				<i>Pounds.</i>	<i>Pounds.</i>
Whole corn	Winter ...	3	8	229	784
Corn meal	Summer ..	5	12	71	534
Corn meal	Winter ...	3	8	177	517
Barley meal	Winter ...	4	12	159	567
Shorts	Summer ..	1	3	58	525
Sweet skim-milk	Summer ..	2	4	66	1,877
Half bran meal, half shorts (dry)	Fall	4	12	137	531
Half corn meal, half shorts (wet)	Fall	4	12	136	431
Corn meal and sweet skim-milk	Summer ..	5	10	95	{ *147
					{ †892
Corn meal and sweet skim-milk	Summer ..	4	10	254	{ *379
					{ †189
Corn meal and sweet skim-milk	Summer ..	4	10	251	{ *432
					{ †216

* Meal.

† Milk.

CHURNING TESTS, S. M. BABCOCK, PH. D. (pp. 111-121).—The following conclusions were drawn from the experiments:

(1) From the result of these tests we may conclude that ripening of cream before churning increases the yield of butter from 15 to 20 percent over the yield from sweet cream, provided both are churned in the same way. At the same time the ripening of cream appears to have no marked influence upon the time of churning.

(2) The mixing of sweet cream with sour cream just before churning does not result in any advantage to the sweet cream, the same loss being incurred as when each cream is churned separately.

(3) The same increase in the yield of butter produced by ripening the cream may be obtained by the addition of acid to sweet cream just before churning.

LAND PLASTER, S. M. BABCOCK, PH. D. (pp. 121-123).—This article contains an account of analyses of land plaster to determine the purity of different brands of plaster sold in the State.

A NEW METHOD FOR DETERMINING FAT IN MILK, F. G. SHORT (pp. 124-136).

Theory of the process.—The process depends on the following facts: That when a mixture of milk and a strong alkali is heated to the temperature of boiling water for a sufficient time, the fat of the milk unites with the alkali and forms a soap which is dissolved in the hot liquid; and at the same time the casein and albumen are disintegrated and become much more easily soluble. After the heating has continued for about two hours the mixture of milk and alkali becomes homogeneous and of a dark-brown color. On the addition of an acid the soap is decomposed, the fatty acids are set free and rise to the surface, while the albumen, casein, etc., are first precipitated and then dissolved. The insoluble fatty acids, thus obtained, constitute very nearly 87 per cent of the total fat in the milk.

Apparatus.—The process requires the following apparatus:

(1) Tubes, Fig. 1, made of soft lead glass about one-sixteenth inch thick; the lower part of the tube being about 5 inches long and fifteen-sixteenths of an inch in

diameter; the upper part of the tube 5 inches long and one-fourth inch inside diameter.

(2) Three pipettes, Fig. 2, one holding when filled up to the mark B, on the neck, 20 cubic centimeters (about two-thirds of an ounce), this being the exact amount of milk to be taken for analysis; the other two pipettes holding 10 cubic centimeters each, for measuring the alkali and acid used.

(3) A scale, Fig. 3, divided in millimeters for measuring the column of fat, when the analysis is finished. The one used by the writer is a folding boxwood rule; but any rule divided in millimeters will answer the purpose.

(4) A water bath, Fig. 4, made of sheet copper. It is provided with a rack to hold the tubes while being heated, also a feed and overflow (C) to keep the water in the bath at a constant level. In the cut the side is broken away to show the rack and method of supporting the tubes in the bath.

(5) A wash bottle, Fig. 5, to hold hot water.

Solutions required.—The solutions required for the process are as follows:

No. 1. 8.75 ounces (250 grams) caustic soda and 10.7 ounces (300 grams) caustic potash dissolved in 4 pounds (1,809 grams) water. Use ten cubic centimeters of the solution for each analysis.

No. 2. Equal parts of commercial sulphuric and acetic acids. The acetic acid should be of 1.047 specific gravity. Use 10 cubic centimeters of the mixed acids for each analysis.

DIRECTIONS FOR ANALYSIS.

Taking samples.—Mix the milk thoroughly by pouring from one vessel to another, avoiding as much as possible the formation of air bubbles; warming the milk to 80 or 90° Fahr. will prevent frothing to a large extent. After mixing allow the milk to stand one or two minutes, to permit the air bubbles to escape before taking samples. Fill the 20-cubic-centimeter pipette, Fig. 2, by placing the lower end in the milk and sucking until the milk rises in the tube above the mark on the side. Place the finger quickly on the top of the tube and allow the milk to run out slowly, until it falls to the mark on the side of the tube, then let the contents of the pipette run into one of the analytical tubes, Fig. 1, blowing out the last few drops.

Adding the alkali.—Fill one of the 10-cubic-centimeter pipettes to the mark on the side, with alkali, and allow the solution to flow into the milk just measured. Place the finger on the top of the tube and shake the tube until the milk and alkali are well mixed. A rubber cot on the finger will protect it from the action of the alkali. Treat all samples in the same way. Place the tubes in the rack B, in Fig. 4, set the rack and tubes in the water bath, Fig. 4, and heat the bath until the water boils; continue boiling for two hours, or until the contents of the tube become homogeneous and of a dark-brown color similar to that of sorghum molasses. After the tubes have boiled for one hour remove the rack and tubes from the bath and examine the tubes to see if the contents are well mixed. If a whitish layer of casein and fat is found floating on the surface of the liquid, gently shake and roll the tubes till the contents are well mixed. Return tubes to water bath and boil one hour. The tubes are then ready for the addition of the acid.

Adding the acid.—Remove the rack with the tubes from the water and allow them to cool to about 150° Fahr. Then, by means of the pipette, add 10 cubic centimeters of the acid mixture to each tube, slowly, so as not to cause the contents of the tube to froth over. Mix the acid with the contents by running a small glass tube to the bottom of the mixture and blowing gently. Place the rack and tubes again in the bath and heat to boiling for one hour. Remove the tubes from the water and then by means of the wash bottle, Fig. 5, fill the tubes with *hot* water to within 1 inch of the top. The fat will then rise to the top of the water. Replace the tubes in the bath and allow them to stand in the hot water, without boiling, for one hour. At the end of this time remove the tubes from the bath, one at a time, and measure while hot.

Measuring the fat.—By reference to Fig. 6, the reader will observe that the lines C and D, representing the upper and lower limits of the column of fat, do not extend straight across the tubes, but are slightly curved. In measuring the column of fat, place the rule on the tube so that the line D will come opposite the lowest part of the curved line of the fat, D, Fig. 6; then read up the scale to the division coming opposite the lowest part of the curved line C, Fig. 6. The number of divisions on the rule between C and D is the length of the column of fat in millimeters. The per cent of fat in the milk is then calculated from the following formula and data:

Amount of milk taken, 20 cubic centimeters. Specific gravity of milk, 1.032. Specific gravity of insoluble fatty acids, .914. Per cent of insoluble fatty acids in butter fat, 87. From the above data we have the following formula:

$$(\text{No. 1.}) \quad 100 \frac{a \times b \times c}{d \times e} = x$$

Where a = the length of the column of fat in millimeters. b = the value of one linear millimeter of measured fat expressed in cubic centimeters. The value of b will vary, according to the size of the tube used. c = specified gravity of the insoluble fatty acids. d = 20.64 grams, or the volume of milk taken for analysis multiplied by its specific gravity. e = per cent of insoluble fatty acids in butter fat. x = per cent. of fat present in sample of milk taken for analysis. Substituting the figures obtained by an actual analysis the formula would be

$$(\text{No. 2.}) \quad 100 \frac{30 \times .027 \times .914}{20.64 \times .87} = x = 4.12$$

per cent of fat in sample of milk analyzed.

In practical work the above formulas would be done away with, and one simple factor used instead.

The article contains illustrations of the apparatus used and also accounts of tests made at this Station and elsewhere to determine the accuracy of these processes as compared with the gravimetric method of analysis.

ON THE AMOUNT OF FAT PRESENT IN CREAMERY BUTTER, F. G. SHORT (pp. 136–138).—This article contains analyses of creamery butter from different parts of the State made to determine the purity of Wisconsin butter. The following shows the average results of analyses of fifteen samples:

Water	11.86
Fat.....	84.54
Casein, salt, etc.....	3.57

NOTES ON FORAGE PLANTS, F. G. SHORT (pp. 138–141).—This article contains notes on prickly comfrey, cow-pea, and miscellaneous feeding materials, and includes tables of the analyses of these forage plants and feeding materials.

ON THE EFFECT OF DEHORNING MILCH COWS ON THE PRODUCTION OF MILK AND BUTTER, F. G. SHORT (pp. 142–153).—The following are the conclusions drawn from the experiments reported in this article:

We have, then, as the result of dehorning twelve cows: (1) A slight falling off in the milk yield, (2) an increase in the fat, and (3) an increase in the temperature of the animal, denoting a slight degree of fever, for a few days after the operation. While these results are not conclusive, yet they indicate that dehorning a well-fed healthy cow is not by any means a serious operation, and unless further experiments

show a more marked injurious effect on the animal than the one given above the question of dehorning cows will depend entirely on the practical advantages to be derived from it. If by dehorning we can insure an economy in feed and storage, as has been claimed, and if at the same time there is no perceptible falling off in quality and quantity of the milk, then the operation will be one of personal convenience. One thing should, however, be taken into account, and that is the condition of the animal. A cow that is poorly fed or out of condition is certainly in no condition to undergo an operation of any sort, nor will there be any benefit derived from it. The question of injury to the constitution or temperament of the animal can only be settled by experiments on a large number of animals, extending over several years.

PLAN FOR A HOG-HOUSE, L. H. ADAMS, (pp. 154-157). (Illustrated).

THE STATION VINEYARD, W. A. HENRY, B. AGR. (pp. 157-163). (Illustrated).—This article contains practical directions for the management of a vineyard and an account of the varieties of grapes tested at the Station.

COMPOSITION OF FEEDING STUFFS, F. W. A. WOLL, M. S. (pp. 164-172).—This article contains explanations of the compositions of feeding stuffs and gives the feeding standards in a form intended for the general reader.

METEOROLOGICAL OBSERVATIONS (pp. 172-175).—The report contains a summary of the meteorological observations taken at Washburn Observatory, Madison, Wis., during 1887, and for the period of 1869-1887.

Summary of meteorological observations from 1869 to 1887, inclusive, by years.

[N. B.—See remarks at end of the table.]

Year.	Mean yearly barometer.	Mean yearly temperature.	Highest temperature of the year.	Lowest temperature of the year.	Range of temperature for the year.	Rain or melted snow.	Mean relative humidity.	No. days on which rain or snow fell.	Prevailing wind.	Maximum velocity of wind per hour.	Yearly movement of wind.
	<i>Inches.</i>	°	°	°	°	<i>Inches.</i>	<i>Per ct.</i>			<i>Miles.</i>	<i>Miles.</i>
1869.....	28.966	42.9	89	—11	100	43.27	79.2	103	NW.	45	.....
1870.....	28.920	47.2	98	—13	111	27.83	69.5	93	NW.	35	.....
1871.....	28.903	46.1	91	—15	106	29.51	70.7	103	W.	35	.....
1872.....	28.897	44.4	92	—28	120	22.44	73.9	87	SW., NW.	35	.....
1873.....	28.893	43.8	91	—21	112	26.49	76.5	80	NW., SW.	35	.....
1874.....	28.950	45.5	96	—15	111	29.02	74.1	85	S. W.	35	.....
1875.....	28.917	42.4	86	—25	111	22.59	74.2	100	W., SW.	25	.....
1876.....	28.921	46.1	90	—22	112	36.04	78.3	93	NW., SW.	35	.....
1877.....	.....	47.7	88	—16	104	27.67	77.3	84	SW.	25	.....
1878.....	.....	49.7	92	—9	101	39.54	71.7	104	NW.	50	[23,132]
1879.....	28.993	47.9	91	—22	113	35.10	68.7	108	S.	48	87,425
1880.....	28.989	48.1	93	—21	114	46.72	70.0	138	S., W.	50	90,855
1881.....	29.001	46.9	95	—20	115	52.92	72.4	158	NW., S.	45	84,312
1882.....	29.005	47.1	87	—13	100	42.89	75.3	160	NW., W.	48	85,448
1883.....	29.006	42.3	89	—23	112	39.84	77.9	121	NW., S.	60	[60,138]
1884.....	28.992	43.4	86	—27	113	49.19	77.8	144	S.	78	93,983
1885.....	28.969	42.1	90	—25	115	40.58	77.2	114	S., NW.	72	93,126
1886.....	28.992	44.8	100	—26	126	28.78	75.0	115	NW., S.	45	90,145
1887.....	28.983	44.9	94	—29	123	38.89	79.2	132	NW.	60	87,761
Means	28.958	45.4	91.5	—20.1	112	35.74	74.7	112	.....	45.3	89,132

REMARKS.—For 1878 the maximum velocity of the wind and number of miles traveled were observed for October, November, and December only.

For 1883 the same data are for 233 days only; the maximum and minimum thermometer and range of temperature for 323 days. The other data for 328 days.

The mean barometer, temperature, rain-fall, humidity, number of days on which snow or rain fell, are given from all the data 1869-1887. The mean highest and lowest temperature, the range, and the maximum velocity and number of miles traveled by the wind relate only to the years 1879-1887.

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